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ACCOMMODATION AND INSTALLATIONS

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By Command of the Army Council,

H. J. Creedy

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MILITARY ENGINEERING

VOL. VII

ACCOMMODATION AND INSTALLATIONS

INTRODUCTION

1. The military engineer may be called upon to provide a wide range of accommodation and installations, whether in a theatre of war or at home. In this volume the term "accommodation" is intended to include all forms of temporary accommodation under the general heading "Camps"; permanent cantonments and barracks are not included.

Under the term "installations" are included hospitals and depots, productive installations such as forestry and saw-mills, brick and lime manufacture, workshops, etc.; and miscellaneous work which may fall upon the engineer and is not dealt with specifically in other volumes of Military Engineering.

2. The factors which govern the provision of accommodation and of any particular installation are usually threefold, viz.—

i. Military considerations.
ii. Considerations of hygiene and morale.
iii. Engineer considerations.

Every problem is unique, and it is the duty of the authority responsible for the provision to strike a just balance where these factors conflict.

The first will always be dominant in the theatre of war, more especially in forward areas, and the second at home; but in no case can any of them be neglected, and the third will always be found to impose a limit on the other two.

3. In every case the problem confronting the engineer is to decide :—

i. to what extent the principles of permanent construction or of peace time production should be modified to meet particular conditions;
ii. the best way to provide what is required in the shortest time with the labour and material available.

The object of this volume is to present the various factors governing the provision of all classes of accommodation and

of any installation likely to be required in the field, in such a way as to enable a correct decision to be arrived at in each particular case.

4. The volume comprises six parts, with supplementary appendices and plates.

PART I.—**General principles governing the provision of accommodation in war.**—Explaining the principles upon which accommodation is provided (i) overseas—at the base, on the lines of communication, and in forward areas; (ii) at home—in war and peace training camps; the factors governing the priority and scale of such accommodation; and the class of work which will devolve upon the engineers in connection with its provision.

PART II.—**Camps.**—Containing chapters relating to the siting and lay-out of camps, provision of services, scales of accommodation applicable (with the modifications necessitated by particular conditions) to all classes of camp, whether in a theatre of war or at home, and the organization for work.

PART III.—**Constructional details.**—Dealing with the design, production and method of construction of various types of hut and of accessories for all classes of camp.

PART IV.—**Hospitals, miscellaneous camps, and depots.**—Dealing with the various factors concerned in the provision of hospitals, special camps and various depots.

PART V.—**Productive installations.**—Dealing with those installations which may have to be instituted in a theatre of war under various conditions to enable an expeditionary force to exploit local resources and lessen the dependance on shipments of commodities overseas.

PART VI.—**Miscellaneous engineer work on active service.**—Dealing with those services which may fall to the lot of a military engineer on active service which do not normally form a part of his peace time work and are not covered in other volumes of Military Engineering. It contains chapters on the work which may be required in connection with the development of a base, and for the Royal Air Force, and it also contains information on various mechanical appliances utilized in the handling of material.

5. The following military text-books are referred to, and should be studied concurrently with this volume:—

i. Manual of Field Engineering, dealing principally with accommodation, sanitary measures, etc., which can be carried out by the troops themselves with materials available locally, or supplied to them by the engineers, and with very little engineer assistance.

ii. Manual of Engineer Services (War), dealing with the organization of engineer work in war.
iii. Military Engineering, Vol. V (Roads).
iv. Military Engineering, Vol. VI (Water Supply).
v. Military Engineering, Vol. VIII (Railways), dealing with the railway lay-out of a base and its various depots and workshops.
vi. Army Manual of Hygiene and Sanitation, dealing with the sanitary requirements of the Army.
vii. Text Book of Mechanical Engineering.
viii. Text Book of Electrical Engineering.
ix. R.A.S.C. Training, Vols. II (War) and III (Supplies), as regards the organization and operation of R.A.S.C. depots and workshops.
x. Ordnance Manual (War), dealing with the organization and operation of R.A.O.C. depots and workshops.

PART I.—GENERAL PRINCIPLES GOVERNING THE PROVISION OF ACCOMMODATION IN WAR

CHAPTER I

GENERAL CONSIDERATIONS

1. Base personnel

1. A British army in the field normally operates from an overseas base or bases, round which are grouped its supply stores and depots, reinforcement camps and base hospitals.

2. In the event of a major expedition or a national war, considerable expansion of the initial force must be expected.

3. The organization required at a base for any considerable number of divisions involves an administrative effort for which large numbers of personnel, especially labour, are required. With the object of freeing fit personnel of suitable ages for the fighting zone, such labour will probably be recruited from the older and less fit categories and, where circumstances allow, in part at any rate from local sources of labour.

The latter may or may not require accommodation, according to local conditions, although it will generally be found that, at any rate with native labour, better results will be obtained if the unskilled workers at least are concentrated in labour camps. With the former a comparatively high standard of accommodation is advisable in order to minimize sickness.

4. For such base personnel accommodation will be required which will probably remain on the same site throughout the campaign, in *Standing Camps.*

2. Line of communication personnel

1. The degree of permanence of the accommodation on the line of communication will vary according to the nature and duration of the operations. As operations proceed and the line of communication extends, temporary accommodation will be required immediately, but as a general rule the policy will be to replace this by more permanent accommodation as time, labour and materials permit.

2. Standing camps may also be required at fixed points along the line of communication for the accommodation of personnel moving to and from the fighting zone.

Except for the permanent staff of these camps (if any) the accommodation provided in these cases would approximate to that in forward areas.

3. Fighting troops

1. Accommodation for fighting troops will vary according to the military, local and climatic conditions. During open warfare in a populated and developed country the bulk of the troops may be accommodated in billets. When billets are not available, accommodation may be in the nature of shelters only, or the troops may have to bivouac for considerable periods.

2. The arrangements made for accommodation must, however, have due regard to climatic conditions and to the effect of these conditions on the health and morale of troops.

3. Either climatic conditions (winter, hot, or rainy season) or military conditions (such as a pause in operations, or a siege, or a period of position warfare) may involve the provision of temporary camps, either hutted or tented or both, if billets are not available or are insufficient.

4. Limiting factors

1. In considering the nature of the accommodation to be provided for large numbers of troops in a theatre of war overseas, it is essential to realize that the choice will be determined by four main factors, viz. :—

i. The time available for construction.
ii. The labour available.
iii. The materials available.
iv. The transport available.

2. It is useless to design accommodation without taking all these factors fully into account. Whilst (i) and (ii) will always be limiting factors in the construction of standing camps at a base, (iv) will usually be the dominant factor for temporary camps in forward areas.

3. It is obvious from a consideration of these limiting factors that the utmost use and development of all local resources are essential.

For reasons of discipline, and often of hygiene, it is unsatisfactory to have troops in billets, even if available, in a base or on the line of communication, but many organizations can conveniently be so accommodated with great reduction in the demand which would otherwise be made on engineer resources.

Typical of such organizations are headquarters of formations, various administrative offices, and small organizations such as N.A.A.F.I., etc.

5. Conditions governing the standard of accommodation

1. The construction of camps in a theatre of war will be governed by conditions which differ materially from peace conditions.

2. Owing to the inevitable congestion, especially at bases, the choice of sites will be very limited. At the same time every effort must be made to secure adequate dispersion in view of the favourable target which a congested area offers to air attack.

3. Owing to the limiting factors enumerated in Sec. 4 the standard of accommodation must be reduced to a minimum compatible with a reasonable standard of health. This reduction will be not only in the scale of provision but in the general quality of material, construction and finish. In this respect a lower standard of accommodation must be visualized in forward areas than in the line of communication area because :—

- i. the more transitory nature of camps in the forward areas renders it desirable in the interests of economy to restrict accommodation to the barest necessities compatible with health and morale;
- ii. limitations of rail and road transport usually permit of only light construction in forward areas if all troops are to be accommodated.

4. Whereas peace cantonments are normally begun and completed consecutively, troops being moved into them after completion, in war it will usually be necessary to construct camps on sites already occupied by the troops.

In consequence it will be necessary to construct many camps concurrently, erecting as a normal procedure first the essential accessories (such as latrines, ablution places and cookhouses) in all camps, subsequently less essential accessories (such as dining rooms and messes), and lastly huts for personnel (on the assumption that personnel can up to such time be accommodated in tents).

5. Whilst at first it will be impossible to provide anything beyond the absolute essentials, nevertheless, after all necessary accommodation has been provided, the duration of the campaign may justify a considerable improvement in the standard of accommodation for the preservation of health and morale.

Under these conditions huts may be provided with linings and fireplaces, canteens built, and so on, and a progressive programme of improvements put in hand.

Each case must be treated on its merits, and what is reasonable in one case may be quite unjustifiable in another.

CHAPTER II

SUPPLY OF MATERIALS

6. Sources of supply

1. Building materials will be received in a base engineer store depot from the following sources :—

i. In bulk from depots in the United Kingdom.
ii. From local sources.
iii. From ordnance base depots (*e.g.* nails, paint, etc.).

2. In the early stages demands on shipping for the conveyance of the expeditionary force and its stores and ammunition will be such as to make it almost certain that only a relatively small cargo space will be available for building materials.

3. It will therefore be one of the first duties of the Director of Engineer Stores to institute an engineer reconnaissance of all possible sources of supply in the area, if this has not already been done before the campaign, and to arrange for the requisitioning or purchase of all suitable materials.

4. This reconnaissance will include all factories, *e.g.* forests and saw-mills, brickyards, lime-kilns, cement works, stone quarries, sand-pits, engineering workshops, together with notes on present production, if any, and possibilities of development.

This is dealt with in greater detail in Part V.

5. It is essential that the first consignments of building stores from home depots should be confined to those materials required in the preliminary stages, *i.e.* normally those required for the development of the overseas base ; and these requirements should therefore be worked out as part of the original plan of campaign before the embarkation of the expeditionary force, and should be despatched early.

Certain details of requirements for typical depots, workshops and unit camps are given in Appendices VI to X.

7. System of distribution

1. From the base engineer store depot, materials will be despatched normally by rail, in quantities determined by G.H.Q. to :—

i. R.E. parks in forward areas, and
ii. R.E. parks in base and line of communication areas.

2. From these parks distribution will normally be made by road to the site of the work.

8. Standard stores

The materials received from overseas in depots and parks will as regards types normally consist of standard stores, listed in an engineer store vocabulary.

Primarily they will consist of the following:—

Timber, unwrought in scantling of all dimensions up to 16 in., and lengths up to 25 ft.
Planking, 4 in. by 1 in.
1-in. flooring and ¾-in. matchboarding in very limited quantities.
Pit props 10 ft.–12 ft. by 6-in. diameter.
Road slabs, hard wood, 2½ in. thick.
Corrugated iron, galvanized and plain, 22 and 24 gauge, 6-ft.–9-ft. sheets.
Roofing felt.
Doors and sashes.
Furniture (locks, hinges, latches, etc.).
Fitments (cooking ranges, stoves, baths, etc.).
Tar.
Nails and screws.
Mild steel of assorted sections.
Rolled steel joists.
Cement.
Glass, and glass substitutes.
Electrical stores (wire, lamps, etc.).
Water piping (4-in.–2-in.–1-in.) and fittings.
Standard huts (*see* Chapter XIII, and Appendix IV).
Tools.

9. Restriction on design

1. Designs must conform to and embody the type of stores available in the theatre of war.

Works programmes must also be drawn up so as to limit the scope of works to the quantities of stores allotted by superior authority.

In fact, as in peace restrictions are imposed by the funds allotted to an engineer officer, so in war similar restrictions are imposed by the limited materials placed at his disposal. (*See* Sec. **69**.)

2. A further limitation is placed on design by local materials and labour.

As stated in Sec. **6**, 3 and 4, and in Sec. **1**, 3, the utmost use will have to be made of local materials and labour.

In many parts of the world special types of building, etc., will be found, constructed of indigenous material suitable to local climatic conditions and to the capacity of the local

workman with his perhaps primitive tools, *e.g.* the log-hut of Canada, the mahteef hut of Iraq, the houses of mud-brick with flat roofs peculiar to Egypt, and the ant-heap floors and beehive huts of South Africa.

In all such cases, therefore, local practice should be followed as far as possible, and local artisans and material employed to their greatest extent.

The use of overseas stores and the employment of the more highly skilled personnel can then be confined to the larger and more important buildings, for which local types of construction may prove unsuitable.

It is seldom worth while attempting to teach a native artisan the use of tools other than those to which he is accustomed.

3. In order to facilitate the quick provision of certain types of buildings which may be required in large numbers in a theatre of war, the designs of these buildings have been standardized, and working drawings and lists of quantities have been prepared for them and sealed.

A list of the buildings, etc., for which working drawings have been prepared and sealed is given in Appendix IV.

CHAPTER III

BASE CAMPS FOR PERSONNEL

10. Initial requirements

1. The Manual of Engineer Services (War) depicts the general situation at a base on the arrival of the first troops, and schedules the probable engineer services which will have to be executed concurrently.

These may differ in degree according to whether it has been possible to bring into use a port as a temporary base apart from that selected as the permanent one or not (F.S.R., Vol. I) ; but initial requirements will be similar in either case.

From this it will be seen that :—

i. only a minor portion of the personnel and stores available can be diverted to the development of accommodation ;

ii. the fighting formations will normally concentrate forward from the base ; and in these concentration areas accommodation will be found for the troops in billets or shelters with the assistance of their own field engineers, and with such material as they can obtain for themselves in the areas allotted to them ;

iii. base personnel, such as technical personnel and labour for operating the several base depots and installations, must be despatched on arrival at the port direct to camp sites (or possibly billets in the case of a temporary base), earmarked for them in the vicinity of the depots in which they will work ;

iv. a transit camp will be required in the vicinity of the base port for troops on disembarkation ;

v. the camp sites referred to in (iii) and (iv), above, will be distributed over a considerable area at distances from the port varying from 1 mile to 6 (or more) miles (*see* Sec. **5**, 2), whereas billets will be concentrated near the port ;

vi. in the case of a permanent base, these camp sites, once selected, will almost certainly remain as camping grounds for the duration of the war.

2. The stores which will be received first into depots in the United Kingdom under War Office arrangements will consist of those obtainable at any moment in the open market, and such ordnance stores as nails, screws, paint and canvas.

3. Of such materials the Director of Works will indent to provide a first supply in the theatre of war (*see* Sec. **6**, **3** and **5**).

He will therefore have to consider what engineer works must be provided from the outset in order to preserve the health and morale of the troops and base personnel.

4. It can be assumed that base personnel, as well as fighting troops, will be able, with the aid of ordnance stores (tentage, etc.), practically to provide their own accommodation for some months, except in the case of severe climatic conditions.

5. The following services, however, will always be required at a very early stage :—

i. Arrangements to prevent the indiscriminate fouling of the soil within selected camp areas.
ii. Water supply.
iii. Cooking shelters.
iv. Entrance and exit roads to camps.
v. Electric light and power.
vi. General improvements to and adaptation of requisitioned buildings as billets, etc.

11. Priority of work on accommodation

1. **Phase 1.**—Save in exceptional climatic conditions, tents provide healthy accommodation for personnel, marquees are suitable for messes and stores, and canvas for latrine screens, etc.

Even if severe climatic conditions exist at the opening of the campaign, there will usually be no alternative in the first instance to this type of accommodation.

During the first phase, therefore, troops will provide their own accommodation. This will include the provision of trench latrines, lamps and lanterns, the transport of drinking water from the nearest available supply, and the use of streams and ponds for washing purposes, and for watering animals.

2. **Phase 2.**—In the second phase engineer resources will be directed to the provision of the following :—

i. Fixed latrines, on the bucket system, and incinerators.
ii. Fixed cookhouses and ablution rooms.
iii. Roads to, and roads and paths in, camps.
iv. Internal piped water distribution systems. (Water supply is dealt with in Military Engineering, Vol. VI.)
v. Internal wiring systems for electric light. (Supply of current is considered in Part V.)
vi. A drainage system to carry off sullage water. At this stage it will probably be possible only to drain off to soak pits.

The above services are not stated in order of priority, as all should be executed concurrently.

3. **Phase 3.**—This phase involves the substitution of hutted accommodation, instead of marquees and tents, for hospital wards, offices, messes, dining rooms, canteens and regimental stores, and the provision of necessary stabling.

It is desirable that this work should be put in hand as early as possible, in case heavy demands for building materials should arise in the forward areas.

4. **Phase 4.**—Assuming that the construction of depots, hospitals, store sheds and offices (*see* Chapter IV) has also been completed, there will now remain under canvas only the sleeping quarters of all ranks, a situation which may well be tolerated (except in certain tropical countries, or otherwise in weather of abnormal severity) for a considerable period.

The fourth phase consists of the provision of sleeping huts for both fighting troops and base personnel, and involves the mass production of standardized huts, which is dealt with in Chapter XIII and Appendix IV.

12. Foul areas

Until fixed latrines, incinerators and a sullage system have been provided the troops will necessarily foul some small area. This area must afterwards be clearly demarcated by *fouled area* notice boards (difficult to remove, and non-inflammable, if possible) to ensure that no living tents or huts are subsequently erected on it. Fouled areas should be recorded on all camp plans.

13. Selection of camp sites

The selection of camp sites will be influenced by considerations of administrative convenience and elementary sanitary principles, and of the target offered to air attack.

The Director of Works must consequently be prepared to subordinate such engineer considerations as proximity to existing sources of water supply, and electric power. Consequently such camps may require a separate water supply and power plant, although the possibilities of a H.V. distribution system from a central plant, and of a centralized water supply system, must always be borne in mind. (*See also* Chapters VIII and XXXI.)

14. Lay-out and scales of accommodation

1. The principles affecting the lay-out of camps are considered in detail in Chapter IX.

2. Type lay-outs for certain camps are given on Pls. **1** to **9**. About the same area is required for either huts or tents.

3. Appendix I gives information for determining the scale of construction for any particular camp.

4. Appendix II gives a synopsis of the scale of building for various camps under the headings *partially hutted* (Phase **2**), and *hutted* camps (Phase **4**).

Reference is also made to type plans (Pls. **10** to **19**), which show the size and design of various typical buildings.

5. Appendix III gives a scale for the provision of electric light in various classes of buildings.

6. Appendix VI gives a list of materials required for the construction of accessory buildings in various unit camps.

7. Appendix VIII gives a list of materials required for the construction of a hutted camp for 1,000 men.

CHAPTER IV

BASE ACCOMMODATION OTHER THAN FOR PERSONNEL

15. Accommodation required

1. Concurrently with the construction of standing camps for personnel, accommodation will have to be provided at the base for the various services, viz. :—

i. Supply depots.
ii. Engineer store depots.
iii. Ordnance depots.
iv. Ammunition depots.
v. Remount depots.
vi. Transportation stores depots.
vii. General hospitals.
viii. Veterinary hospitals.
ix. Repair workshops.
x. M.T. depots.
xi. Bakeries.
xii. Laundries.
xiii. Hutted office blocks.
xiv. Detail issue depots for supplies and stores.
xv. Numerous sheds for the accommodation of other installations (the number of which will tend to increase with the prolongation of the campaign), for example, electric power stations, water pumping stations, petrol canning installations, fat recovery plants, locomotive sheds, and, in hot climates, cold storage and ice plants.

2. Owing to the varied conditions under which campaigns may be conducted it is inadvisable to lay down a standard lay-out and synopsis for supply and other store depots, and M.T. parks.

3. Typical lay-outs for these and other installations are considered in Parts IV and V. (*See also* Military Engineering, Vol. VIII, Railways.)

16. Extensions

It is obvious that progress on all depots will be slow, and that they must be commenced on a moderate scale, commensurate with the labour and materials available. When

depots are being established instructions will be issued by the General Staff as to the degree of expansion for which allowance is to be made.

17. Hutted office blocks

1. At first office work, as well as the sorting of stores which will not bear exposure to rain, must be performed in marquees, if no suitable buildings exist on the site.

2. The preparations of records, statistics, accounts and account vouchers, and the classification and filing of indents constitutes work which is essential to the efficient administration of an army, and which is also essential in order that the commander-in-chief and his staff may be furnished with accurate information as to the reserves of supplies, stores, ammunition and transport available for any contemplated operation. Such work cannot be conducted under canvas for a prolonged period with any regard to efficiency or economy.

Early provision of hutted office blocks for all depots is therefore essential.

18. Hospitals

Although hospitals are fully equipped with tentage for all purposes the provision of hutted operating and X-ray blocks at a very early stage is most desirable on medical grounds, and these should be followed by hutted wards for surgical and serious medical cases as soon as possible.

19. Protection for stores, ammunition and animals

1. The main bulk of supplies and stores can probably be stacked in the open for some considerable time. Some categories, *e.g.* oats and sandbags, require only such cover as can be afforded by tarpaulins or sail covers. Others such as cement require rough shedding. There will, however, always be some which are received in bulk, sorted at the base into bins or pigeon-holes, and issued in detail: these require closed sheds.

2. Many classes of ammunition require protection from the rain, or powerful sun. It is, in general, more economical, financially, to provide open shedding, and this may be required as soon as reserve supplies of ammunition tend to accumulate.

3. It is desirable that remounts, and necessary that sick animals, should be provided with protection from continuous rains or tropical sunshine.

20. Standard universal shedding

1. To assist the Director of Works to meet the demands for early storage accommodation as indicated above with the limited labour and resources at his disposal, standard universal shedding has been designed (Pls. **20** and **21**). This provides a light and rapidly erected roof, supported on poles or other stanchions. Side covering may be added subsequently, as labour and material become available.

It can be readily dismantled and re-erected on another site.

2. First supplies of this shedding may be expected at the base early, but the quantity and time of delivery will be largely dependent on the availability of shipping, and to a lesser extent on the distance of the overseas base from the ports of embarkation ; and the possibility of supplies in no way diminishes the necessity of making the utmost use of local resources.

21. Wide span sheds

If considerable expansion of the original expeditionary force has already been decided on, or if the campaign is likely to be prolonged, it will often prove the best economy to initiate at the outset a more ambitious scheme of construction, by the provision of sheds of standard type and of wider span, commencing with a few bays only, and adding further bays as and when required.

To meet this requirement standard war shedding has been designed, giving a maximum clear span of 36 ft. (*see* Appendix IV).

CHAPTER V

ACCOMMODATION IN FORWARD AREAS

22. Initial accommodation

1. In order to follow the sequence of work it is necessary now to consider the accommodation of the fighting troops whilst the works considered in the previous chapters are in process of execution at the base.

2. It may happen that during this period the fighting troops have been engaged in a series of movements which have not involved any prolonged halts. They will therefore have bivouacked, or in European countries have been accommodated in billets.

3. Concurrently with these movements of the fighting troops one or more lines of communication will have been established with railheads, regulating stations, and possibly advanced bases on them. Work on these points will be on similar lines to that at the base, dependent on the permanency of occupation.

4. Should a period of position warfare occur, demands will be made on the base and G.H.Q. organizations for assistance in the provision of accommodation for the troops. The extent of such demands will depend on the anticipated duration of such a stationary period, on climatic conditions, and on the amount of existing accommodation available.

Should position warfare set in, or any considerable delay occur in the operations from other causes, the dispositions of the troops would probably be as follows :—

i. An *outpost position* would be established, in touch with the enemy.

ii. In rear of this a *main position* would be prepared.

The outpost position would be occupied continuously ; but whilst work would continue on the main position all, or a considerable proportion, of the troops destined to occupy it in the event of attack would probably be in billets in the vicinity. Such a situation would involve the provision of the following accommodation :—

i. Improvisation of shelters and sanitary accessories (Manual of Field Engineering, Vol. I (All Arms).

ii. Improvement of billets (Chapter VI).

iii. Establishment of temporary camps (Secs. 24 and 25).

2

5. In these initial stages accommodation will not necessitate provision from the base of any large quantities of stores, other than timber and corrugated iron, and perhaps stoves.

For troops who must, for military reasons, be accommodated in mere shelters, it may be necessary to supply raw materials, *e.g.* corrugated iron and 3-in. by 2-in. scantling, with which to make for themselves the best cover they can devise suitable to local conditions. The accessories required will be designed in general conformity with the scales and type designs for standing camps, but will be lighter and of a less finished nature.

23. Subdivision of work

1. In billets and bivouacs, the work of the engineers will consist principally of improvements to and organization of the water supply, fixing pumps, and erecting sign posts to water points, latrines, assembly places, etc. The provision of actual accommodation under such conditions generally devolves upon the staff and units, rather than upon the engineers.

2. In the event of a prolonged halt, or of position warfare, the troops will provide most of their own accommodation if supplied with the necessary materials, and, perhaps, some technical advice. In exceptional cases, *e.g.* siege operations, a serious demand for engineer construction may arise.

3. Divisional engineers will probably be employed mostly on defence works and communications, but may be required to assist in establishing more sanitary conditions, and improving the standard of accommodation in billets (Chapter VI).

4. Similar work will be required of engineers in assisting corps and army troops. In addition it will be necessary to develop the water supply in the whole of the corps and army areas.

24. Temporary camps

1. Temporary camps provide accommodation to supplement billets, or to replace that afforded by bivouacs and improvised shelters.

The type and amount of construction will vary according to the anticipated length of occupation and climatic conditions, but such camps tend to expand with a rising standard of accommodation until they may become standing camps ; and the stages of their evolution will therefore follow those laid down for base camps (Sec. 11).

2. The various works and their priority of execution may be grouped as follows :—

i. Water supply.
Latrines.
Ablution places.
Cookhouses.
Horse watering points.
Drainage.
Roads.

ii. Incinerators.
Horse standings.

iii. Drying sheds.
Bath-houses.
Disinfecting arrangements.

iv. Paths.

v. Hutting.

25. Hutted temporary camps

1. If an army remains in one locality for a prolonged period a serious problem will arise in respect of the provision of hutting for troops not accommodated in billets.

2. Military conditions will normally permit, and the absence of billets demand, that a large proportion of the force shall be accommodated in hutted temporary camps.

It may also be the case that personnel at the base have not yet been provided with sleeping huts (Sec. **11**, 4).

3. This general and simultaneous demand will involve the provision of hutting on such a scale that neither skilled labour nor materials are likely to be available in sufficient quantities. A solution of this problem may be sought in the supply on a large scale of standard huts, fulfilling various requirements and involving mass production (Chapter XIII).

4. Where distance from the ports of embarkation or shortage of shipping form insuperable obstacles to this wholesale production from home sources it will be necessary to rely on local resources, and this may involve the manufacture on a large scale of bricks (burnt or mud), lime or cement, the exploitation of local forests, etc.

These are dealt with in Chapters XXVI and XXVII.

5. For forward areas it may be assumed that normally standard huts will be of such simple design that the troops will be able to erect them with little, if any, engineer assistance.

6. Engineer personnel will thus be available for the construction of the essential accessories, and of such additional ones as cinemas and concert huts, and recreation rooms, for which purposes it may be necessary to adopt standard huts or universal shedding.

In view of the impossibility of assuming any standard conditions, such as exist at the bases, it is undesirable to lay down any standard types for such accessories.

CHAPTER VI

IMPROVEMENT OF BILLETS

26. Temporary billets

1. In temporary billets the most important improvements will be those which tend to improve the sanitary conditions and the comfort of the troops, and which the latter are unable to provide for themselves. Tactical considerations may, however, necessitate defensive measures, such as protection against air attack or gas, being undertaken first.

2. In the winter, arrangements for drying clothes, heating, and the erection of cover for baths and clothes disinfection are some of the improvements with which the engineers can best assist the troops.

Much will, however, depend on the type of the billets, the weather, the time of year, and local conditions.

27. Standing billets

1. In standing billets, which may be expected to remain occupied for some months at least, a higher standard of accommodation may be aimed at, involving the construction of bunks in barns, etc., the establishment of brigade and divisional headquarters' offices, the erection of cookhouses and dining halls, and the provision of adequate water supplies, drainage, heating and electric light.

2. If it is anticipated that billets will be occupied for a long period, it is very desirable that recreation establishments and grounds should be provided.

3. Provision should be made in billets for drying wet clothes; if there is no other suitable place a shed may be required, in which disinfectors may be erected and worked.

4. Gas-blanket protection, when required, should be provided for all doors and other openings (Manual of Field Engineering, Vol. I (All Arms)).

28. Bunks

1. When troops are accommodated in barns, warehouses, etc., bunks should be provided (Pl. 26). They should be limited to two tiers, with a minimum distance of 2 ft. between them, and the bottom one should be 1 ft. above floor level, to allow of cleaning. They should be 6 ft. 6 in. long and 2 ft.

6 in. wide, but, where necessary, the width may be reduced to not less than 2 ft.

2. A grillage of hoop iron or plain wire fixed to a framework of 3-in. by 3-in. timber is a convenient form of bunk. The mesh should not exceed 4 in. by 2 in., or the occupants will get the heels of their boots caught in the grillage and damage it.

3. Wire-netting covered with canvas will last for a short time only, and is, therefore, not recommended for general adoption.

4. Hooks and pegs for equipment should also be provided, and, if possible, rifle racks.

29. Dining halls

1. Whenever possible centrally situated arrangements for cooking and dining should be provided for groups of billets. So far as possible peace time arrangements should be followed.

2. Separate dining halls (Pl. **12**, Figs. 1 and 2) facilitate messing arrangements, are easily kept clean, and prevent sleeping rooms from becoming insanitary through food refuse. They should be provided with wash-ups (Pl. **10**, Figs. 8 and 9) for cleaning dining utensils.

3. Billets used as cookhouses can be improved by providing concrete floors, and making doors and windows fly-proof.

4. Grease traps should be provided at all washing-up places.

30. Stables

It will often be found that the ventilation, drainage and flooring of existing stables are unsatisfactory. In such circumstances it is advisable not to use them, but to provide good dry standings at once of brick or stone paving, sleepers, etc., and to erect shelters over them when time and materials permit (Secs. **99** and **100**).

31. Sanitary accessories

1. Ablution benches must be provided, and their sites drained. Grease traps should be provided if the waste water runs into surface drains.

2. Existing latrine accommodation is usually insufficient and insanitary. Other latrines should, therefore, be erected of the usual fly-proof design.

3. Night urinals should be provided, and arrangements made to prevent the fouling of the floor or ground on which they stand. Receptacles for this purpose should be tarred, and will be attended to by the troops themselves.

235.93

32. Heating and lighting

1. Stoves should be provided in cold weather. To obtain economy of heat as much as possible of the flue pipe should be inside the room. If a stove is perforce situated at the end of a long room, the flue pipe should be taken up vertically to a height of about 8 ft. and should then run, suspended on wires, horizontally along the room under the ceiling before being taken through the roof or side. (Sec. 84.)

2. Barns can be made more habitable by cutting out openings and providing windows, which should conform to the arrangements of the bunks, and by making the doors weatherproof.

3. Electric lighting, if available, is the best form of artificial light. If hurricane lanterns are used hanging hooks should be provided.

4. Ample precautions against fire should be taken where artificial heating and dangerous forms of lighting are used. The floors of barns are often in a bad condition, with large cracks between the boards which allow cigarette ends, matches, etc., to drop through. Cracks should be caulked or otherwise closed, and all inflammable material below removed.

CHAPTER VII

TRAINING CAMPS AT HOME

33. War training camps

1. In the event of the expansion of the original expeditionary force into a much larger force (Sec. **1**, 2), a great amount of accommodation will have to be provided at home.

2. The departure of the expeditionary force will have freed a considerable amount of accommodation in existing barracks, which will naturally be made use of in the first instance.

3. The intake of recruits at all centres is likely, however, to be such as to create an urgent demand for immediate extra accommodation.

4. In a war of magnitude existing resources will soon be exhausted, and large camps will have to be created, sited as far as possible where suitable training facilities can be provided.

5. It must be appreciated that men will be coming from civil life—in many cases from sedentary employment—and that the sudden change to the hardships of intensive military training will throw a heavy strain on their physique and morale.

From every point of view, therefore, it is of great importance that every effort should be made to provide as good accommodation as possible.

Whilst, therefore, accommodation must be provided in the sequence as laid down in Sec. **11**, every effort should be made to expedite the final phases.

6. For similar reasons the scale of provision, standard of workmanship, fittings and finish will be higher than at the overseas base. Thus huts would be lined as far as possible, canteen and recreation huts provided, etc.

34. Peace training camps

1. Apart from fixed training camps which exist in many commands, and are provided with semi-permanent latrines, cookhouses, etc., temporary training camps are frequently required for periods from a few days, as on manœuvres, up to a maximum of three or four months.

2. The amount of engineer work required varies in each particular case.

3. In the case of camps for manœuvres it will usually be confined to providing means of access to the site, if not already existing, and to making some arrangements for water supply.

4. In the case of camps for occupation for a fortnight or more, work will normally be limited to the provision of the following :—

i. Water supply and horse watering points.
ii. Cooking shelters.
iii. Ablution benches, with or without cover.
iv. Latrines, probably trench pattern.
v. Improvements to means of access.
vi. Sullage disposal, probably by soak pit.

5. Pl. **19** illustrates the scale of provision considered suitable for Territorial training camps, which are occupied for a maximum of 14 days by any one body of men.

PART II.—CAMPS

INTRODUCTION

1. The principles of temporary construction put forward in the succeeding chapters of Part II apply generally to the provision of all accommodation, whether in or out of a theatre of war. The detail contained in these chapters is not, however, applicable in its entirety to all categories of camp. For instance, Chapter XII (Organization of work), Chapter VIII (Sites), and Sec. **48** (Aspect and prospect), apply primarily to semi-permanent camps in peace time and to war training camps at home, and the majority of the engineering considerations put forward in them will in war time be subordinated to military necessities.

2. The three categories into which camps fall, from the point of view of duration of intended occupation, are as follows :—

i. *Temporary camps* in the forward areas of a theatre of war ; these have already been considered in Sec. **24.**

They may also be required on lines of communication, or at bases during specific operations, at home for manœuvres and short periods of training, and to meet sudden demands for accommodation.

In such cases the evolutionary character of the camps discussed in Sec. **24** will be less apparent. The period of occupation will usually be known in advance, and the standard of accommodation determined accordingly. Time will be short, but labour, material and transport probably adequate. Construction will be reduced to essentials, and be designed to facilitate dismantling.

ii. *Standing camps,* which will normally be required on lines of communication and at bases in the theatre of war. Their development in this connection has been outlined in Sec. **11.**

In addition, they may be required in forward areas when a long period of stabilization is anticipated, in occupied territory, and at home, especially during the periods of mobilization and demobilization.

iii. *Semi-permanent camps,* which may be required on mobilization for additional units, for regular practice

camps, for an army of occupation, etc. They differ from permanent barracks in the following respects :—

(*a*) They will only be required for a comparatively short period, probably not more than 10 years.

(*b*) Details of construction will be simpler, and may involve the adaptation of local materials and types to military requirements.

CHAPTER VIII

SITES

35. General considerations

1. The number of troops to be accommodated and the localities in which camps are to be sited will be decided by the commanders concerned.

The distribution of the troops will be governed largely by considerations which are not of an engineering character, such as the grouping of units in the same formation adjacent to each other, administrative convenience, hygiene, proximity to suitable training areas, etc.; but the general engineering resources of the country, such as water supplies, roads and railways, proximity to labour market, etc., will also affect the distribution, and may often be the deciding factor.

The responsible engineer officer must ensure that all available information which may affect or have an influence on the distribution of the troops is placed at the disposal of the commander.

2. The following factors should therefore be investigated :—

i. The available sites and their relative suitability.
ii. Possibilities of future extensions.
iii. Terms of purchase or lease.
iv. Compensation for damage, etc., to the property to be acquired.

The rentals of public lands are usually less than those of private properties, and it is always more economical for the Crown to use public rather than private land.

3. Recommendations for the actual camp site are usually made by a board of officers on which the engineers and medical service are represented. Many medical and engineering considerations are so closely allied that the closest co-operation between these two services is essential.

The engineering considerations are given in Secs. **36—44.**

36. Acreage

1. In **temperate climates** an approximate allowance of 60 square yds. for each person and major M.T. vehicle, and 110 square yds. for each horse will be sufficient in all ordinary camps. This allowance includes all that is necessary for administration, roads, exercising, parade grounds and all accessory buildings. A battalion of infantry, or, say, 1,000

men, should be given about 12 acres; where space is limited this area may be reduced, but 8 acres should be regarded as the minimum. 1,000 horses, including their personnel, will require from 18 to 23 acres.

Sleeping huts are normally about 20 ft., and stable blocks 30 ft. apart.

2. In **hot climates** it will be necessary to space living huts, stables, etc., up to twice as far apart, and the acreages required will be about 25 per cent. in excess of the above figures.

3. Where possible, however, it is desirable to have natural features as boundaries to the camp area, and this may occasionally increase the areas given above.

37. Water supply

1. Camps should be sited, if possible, near a source of water. The development of an unused source is slow, and may be expensive in time and material, so that, where available, a local water supply should always be utilized, and extended where necessary.

Care must be taken, however, to leave sufficient water to meet the requirements of the civil population.

2. For details of water supply arrangements, *see* Military Engineering, Vol. VI.

38. Drainage

1. Surface drainage will always be required in all camp sites, and the facilities for providing it should be investigated.

2. A water-borne sewage system will never be justifiable at the outset, and would only be installed later in special cases, and where local conditions are favourable.

39. Slope of ground

1. The site for a camp should be fairly level, but absolutely flat ground is difficult to drain.

2. On fairly level ground construction is simple, transport is facilitated, less labour is needed, and the camp can be concentrated.

3. In hilly country buildings must usually be scattered in small groups, which increases the difficulty of administration; good parade and recreation grounds are difficult to find, and more work is needed in constructing roads and laying drains and water pipes.

It may have the advantage, however, of providing a less favourable target to air attack.

4. High ground and the slopes of hills are good sites, but it is as well to avoid the bases of hills, where the air is often stagnant, and the summits, which are often too exposed. The flattest parts of a camp site in hilly country should be allotted, wherever possible, for parade grounds, horse standings and exercising tracks. The altitude of a site for a camp may be determined by the possibility or otherwise of connecting it by a railway siding to a main line.

5. A slight slope facing the afternoon sun is probably the ideal situation; a steep slope facing northwards (in the northern hemisphere) should be avoided, as the buildings would receive very little sun.

40. Nature of soil

1. Sand, gravel and chalk soils make good sites, and being porous are usually very healthy. It is, however, necessary to examine the strata underneath, since, if the porous soil is only lying in pockets over clay, cesspits of decomposing matter will be formed which cannot escape and will become a danger to health.

2. On impervious soils a site must be selected from which storm water will run off naturally. Granite and trap rocks which are sound and free from fissures are quite suitable, although objectionable on other grounds, such as difficulties over foundations of buildings, excavation for pipe lines, etc.

3. Clay and marl do not make good sites, as they are always damp, and consequently tend to be unhealthy, and it is difficult to prevent the surface from being churned into a morass.

4. Trial pits should be dug to ascertain the nature of the underlying strata and the level of subsoil water, which usually varies considerably with the seasons. In some situations subsoil drains may be necessary.

5. Grass surfaces are the best. Tilled, irrigated and made grounds should be avoided, although tilled land may often have to be occupied in preference to pasture to reduce claims for compensation (Manual of Engineer Services [War]).

41. Communications

1. The existence of roads and railways in the vicinity of a camp site is of importance, but it may be better to extend such communications to a good site, rather than occupy an inferior one nearer to the existing communications.

2. If large quantities of materials have to be conveyed for the construction of a camp, the extension of railways or waterways to the site should be undertaken first, wherever practicable; otherwise, the roads may not stand the abnormal

traffic, and their repair will then make a heavy call on labour, while the supply of stone may entail additional demands on transportation facilities which may be difficult or even impossible to meet.

42. Sanitary considerations

1. Sites should not be selected in the vicinity of marshes, cemeteries or sewage farms, or immediately to leeward of towns or villages in undeveloped or Oriental countries, and ground which has previously been occupied should not, if it can be avoided, be chosen for camping purposes.

2. Low-lying meadows and other sites shown to be damp by the presence of rank vegetation, woods containing undergrowth, the bottoms of narrow valleys, and the heads of ravines up which currents blow from the low-lying country, are all liable to prove unhealthy.

3. Ground liable to flood, such as dry river beds, etc., must be avoided at all costs.

4. Sites in the neighbourhood of trees are desirable, but camp buildings should not be erected under them unless concealment from the air is of primary importance.

5. In jungle, the undergrowth should be removed and the ground left clear for as long as possible before building, as a preventive against malaria.

43. Boundaries

1. Natural boundaries are very desirable, especially in a small camp, as they obviate the necessity of erecting fences, facilitate the preservation of discipline, and tend to prevent the entry of unauthorized persons. A stream, a ditch or even a sharp fall of the ground will help to demarcate and isolate a camp.

The possibility of future extensions requires consideration in the first instance.

2. It is undesirable to make use of main roads as boundaries between camps, and, where possible, camps should be sited at least 50 yds. away from them.

44. Enclosure and preparation of the site

1. As soon as a site has been acquired it should be enclosed, if possible ; in any case the boundaries should be marked by posts or stones, and measures taken to exclude unauthorized persons.

2. The site should be cleared of all long grass, bushes, large stones and rubbish before any constructional work is begun. Long grass and bushes harbour insects, hide refuse, make fouling of the ground difficult to detect, and hinder the preliminary work connected with collection of materials, laying-out, etc.

CHAPTER IX

LAY-OUTS

45. General arrangements

1. In all camps intended for long occupation there are three vital necessities—roads, water and drainage. These do not usually affect the lay-out of a small camp, but in large camps which accommodate a number of units the lay-out may be wholly determined by them.

2. The chief considerations affecting the lay-out will then be as follows :—

i. The purpose for which the camp is required, and what transport will serve it.

ii. The units and number of men and horses to be accommodated.

iii. Existing communications and the possibilities of their development.

iv. The amount of water required, the nature of the source and how it can best be conveyed, stored and distributed.

v. The system of drainage to be installed and the method of disposal of sewage ; this will be affected by the nature of the site and soil.

Drainage and water supply should be considered together when the lay-outs of camps are prepared, in order that the routes of drains and water distribution pipes may be planned to the best advantage, and not interfere with one another.

3. The general arrangements of camps can be conveniently divided into two parts, viz. :—

i. The sub-division of a camp area into various unit camps.

ii. The lay-out of the buildings within the unit camps.

4. Recreational facilities should be provided for certain camps, *e.g.* base convalescent camps, base depots, camps for permanent base personnel, and labour camps.

Where possible, the area taken up for each of these camps and the lay-out of the camp itself should permit of the recreational area being within the camp perimeter. In other cases they should be sited within reasonable distance of ground suitable for recreation.

5. Pls. 1 to 9 illustrate the arrangement of huts for various types of camp, but should be taken as guides only, and not as standard plans. The lay-out of every camp must be

considered on its merits, and no rule can be laid down which will be applicable in all cases.

6. Whenever possible an officer of the unit which is to occupy a camp, or of the same branch or arm of the service, should be consulted regarding the suitability of the lay-out, and for hospitals it is essential that a medical officer should be consulted.

7. For camps for non-European troops an officer thoroughly acquainted with their habits should be consulted, so as to avoid interference with their customs.

46. Convenience of administration

1. **Division into groups.**—A camp should be sub-divided into the required number of self-contained groups, each of which should accommodate a unit or some definite portion of a unit.

2. **Accessory buildings.**—Buildings such as cookhouses, ablution places and latrines, should be conveniently situated with regard to their functions, and also with a view to serving a definite portion of the camp.

3. **Water supply.**—All buildings served by the piped water system should be so situated as to permit of a simple and economical distribution system.

4. **Roads.**—Existing roads should be utilized to the fullest extent, *e.g.* stables and stores should be within convenient distance of them.

5. **Guard room, offices, stores and parade ground.**—The guard room should be near the main entrance of the camp, and very often the regimental offices and stores can be conveniently grouped round it.

A parade ground is essential, and will normally be on the most level portion of the area.

The sleeping huts or tents can usually be grouped round it.

6. **Stables** should, if possible, be so sited in respect of the prevailing winds that minimum inconvenience is experienced throughout the year.

7. A long straggling camp is not so convenient to administer as a compact one.

47. Accessory buildings

1. **Latrines and incinerators** should be so sited as to give the least possible inconvenience from odours. Latrines should be well away from cookhouses but not too far from the areas they serve.

Incinerators should be easily accessible for the conveyance of rubbish to them, and within easy reach of supervision when they are intended for the disposal of excreta. There are two methods of siting incinerators. Either an incinerator is built close to each group of latrines, the excreta being dumped direct into it from the latrine buckets, or one central incinerator or group of incinerators is used for the whole camp, the excreta being conveyed in specially-designed receptacles.

Incinerators should, if possible, be placed so that their smoke rarely blows through the camp, *i.e.* on the leeward side in relation to the prevailing winds (Sec. **46**, 6).

2. **Cookhouses** should be sited as far as possible from latrines and close to the dining halls which they serve. Centralization of the cooking arrangements is always economical and a convenience; it is, therefore, better to have one large cookhouse than several small ones.

3. **Separate dining rooms** for men should be provided. If it can be avoided, men should not be permitted to have their meals in sleeping huts or tents, as this practice is detrimental to their health and to the cleanliness of the camp.

4. **Wash-up places** should be attached or adjacent to both dining halls and cookhouses.

5. **Ablution places and baths** may often be economically contained in one building. One central bath-house may, however, be provided to serve several unit camps, in which case separate ablution places will be required for each unit camp.

48. Aspect and prospect

1. **Aspect** is the term used in relation to the siting of buildings with reference to the points of the compass.

2. In **temperate climates** a hut with sides facing east and west will receive the morning and afternoon sun on either side, a great consideration in winter, while in summer the sun's rays are never unpleasantly strong.

3. In **hot climates** it is desirable to protect huts as much as possible from the direct rays of the sun. In summer the sun is high at noon, in the tropics being nearly overhead, and, therefore, if the sides of a hut face north and south, the direct rays of the sun will strike only on its ends in the morning and evening. Overhanging eaves will usually suffice to protect its sides from the direct rays of the sun, but in exceptional cases it may be desirable to give mat verandahs on the south side. In winter the sun is lower at midday, and the side of the hut will benefit from its rays.

It should be remembered that in some countries great heat by day may be followed by great cold at night.

4. **Prevailing winds** also need to be considered. In some parts of the tropics a breeze usually springs up in the evening, and huts should be so sited as to receive the full benefit of it. It may be necessary, therefore, to site them in echelon.

On cold and bleak situations the ends of huts should face the winds.

5. **Prospect** is the view obtained from a hut. It should not be allowed to overrule aspect, and should be considered only when the latter is not affected.

49. Future extensions

1. Well-prepared lay-out plans will allow of the extension of a camp on sound principles. If in the first instance buildings are erected without forethought many of them may be found to be inconveniently sited as the camp develops, and may have to be removed, causing unnecessary waste of time, labour and material.

2. The initial lay-out of roads, water supply, and drainage should provide for the easy extension of the camp.

3. Future extensions are particularly important in the case of store depots and hospitals.

50. Fire prevention

1. Huts are usually constructed of materials of a particularly inflammable nature, and the method of their construction admits of easy access of air; consequently fire will spread quickly.

2. In a large camp groups of huts should be at least 50 to 100 yds. apart; this will assist in confining a fire to the group in which it starts.

The open spaces may be used as parade and recreation grounds. (*See also* Sec. **75**.)

CHAPTER X

SCALES OF ACCOMMODATION

51. General

1. **Purpose.**—It is imperative that there should be scales of accommodation for all classes of camps :—

i. To ensure that all huts are erected under proper authority, and to prevent the erection of unauthorized huts.

ii. To ensure that all troops, horses, etc., are given accommodation on the authorized scale, *e.g.* floor areas, etc.

iii. To facilitate the preparation of type designs, lay-out plans, and other drawings.

iv. To facilitate the preparation of estimates for materials, labour and transport, and the arrangements for their speedy supply.

v. To facilitate the standardization of huts, roof trusses, etc., and the arrangements for their rapid and economical production.

vi. To ensure that all concerned are conversant with what huts, etc., may be erected, thus avoiding confusion, unnecessary correspondence, and delay.

vii. To ensure the best organization and administration, and, consequently, efficiency and economy.

The scales of accommodation given in this volume are included solely as a guide. They are based chiefly on the experience of the British Army in France in the Great War.

2. **Authorization.**—All hutting programmes should be based on approved and authorized establishments.

3. **Fixing of scales.**—The scale of accommodation to be given to troops is fixed by the headquarters concerned, and the engineers will provide accommodation in accordance with the authorized scale ; this scale will not be departed from without the sanction of competent authority.

4. **Planning, etc.**—The scales of accommodation and floor areas allowed should be studied before any planning is commenced. Cubic space is not taken into account in making calculations for camps. Huts are invariably of the bungalow type, and the whole of the interior space from the floor to the eaves and, generally, that above the eaves also is available for accommodation purposes ; further, their design must always admit of the access of a plentiful supply of fresh air. For these reasons superficial areas alone are of importance, and

the floor areas given in Appendix I will be consistent with all applicable hygienic considerations.

5. **Stoves and electric light.**—All living huts, wards and floored marquees should be provided with suitable stoves in all but tropical climates, and if possible with electric light.

52. Schedules

1. Appendix I gives a schedule of the superficial areas allowed for the accommodation of troops, hospital patients, animals, etc., and for accessories, the percentage of seats for latrines and basins for ablution places, and the superficial area or percentage for baths. The design of huts, etc., should be based on this schedule.

2. Appendix II gives scales of accommodation for various camps, and is based on those adopted in France in 1917 for standing camps on the lines of communication. These scales are a suitable guide to requirements in a temperate climate under normal conditions, but should not be regarded as authorized scales to meet abnormal climatic and other conditions.

Variations may be necessary in the scale of accessory buildings on account of scarcity of transport, labour or material.

The plates referred to in Appendix II show how rooms may be arranged suitably under one roof to give the required accommodation. These plates should be used as a guide only, and not as type designs.

3. Appendix III gives a suggested scale for the provision of electric light in camps.

CHAPTER XI

CAMP SERVICES

53. Water supply

1. The initial water supply arrangements must necessarily be of a primitive nature.

The source of supply may be :—

i. Rivers, streams, lakes, etc.
ii. Wells—deep and shallow.
iii. Existing water supply points or town mains.

In all these cases units will fill their water carts and troughs direct from the source of supply in the first instance.

2. At this stage engineer work will be confined to :—

i. **Rivers, streams, etc.**—Improving or providing means of access, and marking watering points.
ii. **Wells.**—Improving pumping arrangements where required—*e.g.* installation of belt pumps (possibly in lieu of bucket, rope and windlass), and small waterproof tanks—or repairs and overhaul of deep well pumps, etc.
iii. **Existing water supply points or town mains.**—The provision of storage tanks, stand pipes, etc., at suitable watering points on the main.

3. Improvements to these initial arrangements should be undertaken as soon as possible. These will usually comprise :—

i. **Rivers, streams, etc.**—The provision of properly sited reservoirs in the vicinity of the camps. This will entail the installation of :—
   (*a*) a power-driven set, and arrangements for working it ;
   (*b*) a rising main ;
   (*c*) reservoirs ;
   (*d*) in some cases means of purification.
ii. **Wells.**—The sinking of 4-in. or 6-in. bore-holes to supplement and improve the supply, with arrangements for delivery to suitably placed reservoirs. This will entail the installation of :—
   (*a*) an air-lift pump, which, with a suitable compressor, will be capable of raising 10,000 galls. of water an hour from a depth of 150 ft. in a 6-in. bore-hole ;

(*b*) a booster pump to force the water along the rising main;
(*c*) a rising main;
(*d*) reservoirs.

iii. **Existing water supply points or town mains.**—Laying a pipe-line to a suitable point in or near the camp. This will entail:—
(*a*) tapping, in the case of a town main;
(*b*) the laying of a pipe-line;
(*c*) the provision of reservoirs.

4. The improvements to the water supply should be progressive, and, as soon as the installations described in para. 3, above, have been provided, steps should be taken to extend them by:—

i. laying pipe-lines from the reservoirs to all points in the camp at which water is used, *e.g.* cookhouses, bath-houses, ablution places, messes, and horse watering points, semi-permanent troughs being fixed at these points;

ii. to ensure economy in material, siting all points requiring water so as to permit of a simple circulating system with as few branches as possible.

5. Military Engineering, Vol. VI, contains all the data necessary for calculations.

6. The necessity for co-ordinating water supply work with other works services in a camp must be emphasized. All pipe-lines should be laid and connections made before the roads are completed to prevent disturbing the surface of newly finished roads. The alignment of the mains and branches should be carefully checked on the site plan to avoid interference with future building operations.

54. Sanitation

1. The proper sanitation of camps is the responsibility of specialist sanitary officers. They are assisted by unit sanitary personnel, and, if necessary, by hygiene sections.

The duties of the hygiene officer include the supervision of food and water supply, the disposal of sewage and refuse, disinfection, and all measures necessary to prevent the introduction and spread of infectious disease.

2. The sanitary methods to be adopted will be decided by the sanitary officer, but the engineers will usually be required to carry out the engineering works necessary for the working of sanitary schemes.

3. These sanitary measures will, owing to the comparative healthiness of camp life, usually be confined to the following :—

i. The purification of water where necessary by filtration and chlorination. (This will normally be done in the unit water carts.)

ii. The provision of a simple form of grease trap at water outlets.

iii. The provision of suitable means of disposal of sullage water—by soak pits in porous soil, or by drain or surface channel to suitable outfalls in heavy soils.

iv. The provision of efficient incinerators for the burning of excreta, offal and camp refuse generally.

v. The surface drainage of the area and of marshy areas in the neighbourhood, particularly in malarial countries.

4. The provision of refuse bins or outdoor wastepaper receptacles (Pl. 27) will assist in keeping a camp tidy.

5. Shortage of material, labour, money or time may limit the amount of work which can be carried out in connection with any sanitary scheme, and the engineer officer must collaborate with the sanitary officer to produce the best practicable results under existing conditions.

55. Disposal of sewage

1. The sewage of camps is usually disposed of by one of three systems :—

i. Water-borne system.

ii. Pail system.

iii. Deep trench system.

2. A water-borne system is by far the best, but its initial cost is very heavy, and it takes a long time to instal. Where the crude sewage cannot be discharged direct into a river or the sea, treatment in a sewage farm will be required.

For these reasons it will only be installed in exceptional cases, such as where connection can be made with an existing disposal system, or when the duration of the campaign justifies it.

3. Where the possibility of a water-borne system is contemplated care should be taken to site buildings which will require drainage, so that they can be connected conveniently with the drainage system.

4. The pail system is the one which will be adopted under normal conditions.

It involves either the incineration of excreta and all refuse, or its removal by cart to a burial or dumping ground.

Incineration is the usual method in military camps. Typical

incinerators are illustrated on Pls. **41–43**. Removal would only be resorted to in the vicinity of large towns, etc., where it could be carried out by civil contract.

5. The deep trench system will normally only be resorted to until it is possible to build incinerators and instal the pail system.

It has the disadvantage of definitely placing a certain area of ground out of bounds for any other purpose, and is therefore most undesirable in a camp to be occupied for any length of time.

With either the pail or deep trench systems it is important to ensure that the latrines are absolutely fly-proof.

6. In certain cases it may be necessary to deal with a considerable volume of sullage, for which the methods indicated in Sec. **54**, 3, ii and iii, are insufficient.

Pl. **28** illustrates a method of treatment on a moderately large scale.

56. Roads

1. Roads are an expensive item in the construction of any camp, and utilize large amounts of labour and transport during construction, and subsequently for maintenance. Careful attention should, therefore, be paid to their planning, and the best use possible should be made of existing roads.

2. The planning of the roads should proceed in conjunction with the lay-out of the buildings, but whether the roads are made to conform to the lay-out or *vice versa* depends on circumstances; in any case, construction should be kept to a minimum, having due regard to the administration of the camp.

3. Main roads should be so aligned that heavy traffic will naturally follow them, and not be tempted to use branch roads as short cuts.

Branch roads need only be sufficiently wide to carry local traffic, and if there is any likelihood that they will be used as short cuts for the main traffic one or two bends may be introduced as a deterrent to fast or heavy traffic.

If branch roads are well laid out and constructed, economy can be effected, both in the initial constructional work and the subsequent maintenance, and the consequent savings can be devoted to the main roads.

4. Standings round water troughs and washing places for motor vehicles should be constructed as carefully as roads; otherwise they may become quagmires.

5. Units should not be allowed to build roads for mechanical or horse transport except under engineer supervision; otherwise the road maintenance will become excessive.

6. Types of roads and methods of construction are dealt with in Military Engineering, Vol. V. The type to be adopted in camps and depots will depend entirely on local conditions. As roads take time to construct it is probable that in most cases a plank or corduroy road will be all that can be provided in the first instance.

57. Footpaths

1. Paths and subsidiary roads are required in camps for conservancy purposes, and for the distribution of supplies.

They should be constructed by the troops with materials supplied to them. Broken brick, gravel, cinders, etc., are suitable; empty preserved meat tins filled with earth and laid like bricks, empty bottles sunk in the ground bottom upward, etc., also make good paths.

2. On muddy sites paths should be laid down to each hut, and scrapers provided to diminish the amount of mud taken into the huts. Trenchboards are invaluable for exceptionally wet sites or where broken brick, gravel, etc., are not available.

3. In soft sand wire netting tracks can be laid down, but under anything but light traffic they require constant attention.

4. Footpaths in hospital grounds should be constructed by the engineers.

58. Lighting

1. Electric light is the most satisfactory form of illumination for hutted camps, and this subject is dealt with in Appendix III and in the Text Book of Electrical Engineering.

2. A complete lay-out plan of the whole camp, showing the proposed buildings and the areas earmarked for future extensions, is necessary to assist the E. and M. officer to plan the transmission lines.

3. Places where external lighting is required such as guard rooms and reception blocks, should be indicated on the plan, and also the roads which require lighting.

4. If oil lamps are to be used, supports or hangers should be provided for them, and precautions taken to prevent them igniting the woodwork of huts.

CHAPTER XII

ORGANIZATION OF WORK

59. General considerations

Whereas in peace cost is usually the primary factor, in war time takes its place.

The necessity of providing what is required in the shortest possible time demands not only the most careful organization of labour and materials, but also an exact knowledge of the output to be expected under varying conditions from men and machines.

The object of organization is to ensure that men, machines and materials are employed to their utmost capacity. This involves not merely the proper feeding of the workman or machine with material, so that there are no moments of idleness beyond those ordered for rest, but the proper proportioning of men to the work, so that there is throughout a regular timed and orderly sequence of operations.

60. The time factor

In order to establish the time which will be required to complete a work, the following factors must be taken into consideration :—

i. The quantity of material on the site ; and the source of further supplies.

ii. The transport available for conveyance of material, and the length and state of the roads or rail to the site.

(These factors govern the amount of labour which can be usefully employed.)

iii. The available labour, and its distance from the site of the work.

iv. The available tools.

v. The individual output of man or machine on each class of work. (Appendix V.)

vi. The supervision available.

vii. Climatic or other conditions which may limit the working hours.

viii. The services available during construction, *e.g.* water supply, drainage and lighting.

Much useful information can often be obtained quickly by

studying municipal and county records and plans of public lands, roads, water supply, drainage and lighting, and by interviewing the local civil authorities and leading building contractors.

61. Civilian labour

1. In almost every case any military labour available will have to be supplemented by civilian labour (*see* F.S.R., Vol. I, 1930, Sec. 71). It is therefore essential to carry out a census of all civilian labour available in the district at a very early date; such a census would be made under orders issued by the Q.M.G.'s branch of the staff.

2. In many countries in which an army may find itself operating as an ally, conscription will probably be found to have swept up most of the labour available, and the remainder will be required mainly for the public services of the country.

In others, or in neutral and hostile countries, labour may be recruited or impressed in large numbers.

In the latter case, and frequently in the former, it will be found more satisfactory to organize labour into formations, and to house and feed the men in suitable centres.

3. In such cases it is important to remember that only a well-fed and contented labour force will render good service, and that its output will vary almost directly with its well-being.

4. Although it will seldom be possible to have a separate labour organization solely for engineer work, it is essential that definite units of that organization should be set aside for this work, and that all skilled building labour be allocated to those units.

Even with unskilled labour far better results are obtainable if the same men are employed continuously on the same class of work than if parties for work are drawn haphazard from a general pool of labour.

This applies with equal force to labour employed in the handling of stores or ammunition, or as road gangs, as to that on building operations.

5. The distance of the available labour from the site of the work is a vital factor, and in many cases it may be desirable to allocate some or all of the transport available to bringing the men to the work before proceeding with the normal duty of transport of stores.

On very large works, a labour camp in the immediate vicinity is almost a necessity.

62. Labour camps

1. Labour camps should be situated as far as possible in a central position with reference to the work of the labour supplied from that camp; in no case, however, should the walking distance exceed 2 miles; otherwise time is wasted and men are unnecessarily fatigued.

2. Workmen must be housed in reasonable comfort, particularly under severe climatic conditions; otherwise the output of work will be greatly reduced, and much trouble and expense will be incurred through absence from sickness and the necessity for hospital treatment.

This will be found more particularly the case with local labour, especially in malarial countries.

3. Although, therefore, workmen may be accommodated at the start in tents with the usual accessory buildings, such as ablution places, cookhouses, latrines, etc., it will normally be found necessary to provide more permanent accommodation in severe weather. The scale of this accommodation will usually be less than that for troops, particularly with local labour, where the local type of dwelling should be copied as far as possible.

4. The sanitation of civilian labour camps requires special attention, as civilians are unaccustomed to discipline and may foul the ground if not well supervised.

5. The lay-out of labour camps will follow the general principles laid down in Chapter IX; and special attention may have to be paid to the adequate dispersion of huts and to the provision of shelter trenches as protection against air attack.

In special cases camps may have to be protected against raids—*e.g.* on the N.W. Frontier of India, and in such cases perimeter camps will be required.

63. General procedure

1. **Site plan.**—When a site has been selected, and the engineer officer informed what troops are to be accommodated, a general site plan of the whole camp will be prepared, allotting areas to the various units and showing the main communications, and water supply and drainage routes. This plan should be approved and signed by the responsible staff and medical officers. When approved, it should not be altered without their authority; this is most important, as unit commanders and local representatives of services and departments frequently ask for sites to be changed, and delays and confusion will arise unless an authoritative plan can be produced.

2. **Lay-out plans and type designs.**—When the general site plan has been approved the lay-out plans of the buildings in each area can be prepared.

The principles laid down in Chapter IX should be adhered to, and it is essential for each plan to be signed by the representative of the Q.M.G.'s branch concerned, as well as by the medical officer.

If type designs do not exist or are unsuitable, they should be prepared at the same time.

3. **Materials and labour.**—When the lay-out plans have been approved the following should be prepared :—

i. Lists of material required.
ii. An estimate of the labour which can be employed, showing details of the number of men of each trade and labourers.
iii. A general programme of the order of work to be undertaken.

Arrangements must be made for the supply of sufficient materials and labour to begin work as soon as the lay-out plans have been approved.

4. **Transport.**—Transport will be required for the conveyance of materials and possibly of labour to the site. Every effort should be made to have at least two days supply of material always in hand at the site to provide for inevitable breakdowns or the requisitioning of transport for emergencies.

It is essential therefore that materials should be brought to the site in the order in which they will be required.

Accumulations of stores which will not be required till later merely lead to congestion of the site, and are liable to be damaged or to disappear.

5. **Engineer offices, stores, etc.**—Before the actual camp buildings are begun, the buildings, etc., essential to the administration and execution of the engineer work should be constructed. These are :—

i. Offices (officers, clerks, draughtsmen, clerks of works, etc.).
ii. Stores (offices, sheds, and stacking areas).
iii. Workshops.
iv. Accommodation for workmen (if required).
v. Latrines.
vi. Railway sidings, tramways and roads.

Existing buildings and sheds may often, with slight alterations, be utilized for some of these purposes.

6. **Engineer offices.**—These should not be in tents, as they admit dust and wind, while plans and documents are

liable to be blown away or mislaid. A well ordered office will facilitate the work.

It will usually be possible to utilize one of the first of the camp buildings to be erected as engineer offices.

7. **Stores.**—Cover for perishable stores is essential, and a locked store shed is required for small stores and tools which are liable to be pilfered. Ample space should be set apart for stacking, as congested stores are difficult to administer. The whole stores area should be enclosed by a fence, and no unauthorized persons should be allowed to enter.

There should be no thoroughfare through the stores yard, and its entrances and exits should be well defined and guarded. Arrangements should be made for the protection of stores by night. Store yards should be situated near the main camp road, and, if materials are brought by rail, should have their own railway siding in order to avoid double handling.

8. **Workshops.**—The size and scope of the workshops will depend on local conditions and on the extent to which it may be decided to manufacture on the site. They should be sited near the stores yard.

9. **Surface drains.**—These should be constructed as early as possible to prevent the ground from getting into a bad condition. Catch water drains may be necessary to intercept water from high ground commanding the site.

10. **Distribution of materials.**—Before large works are begun, arrangements should be made for the economical distribution of materials. If possible, materials should be distributed direct from the store yard to the site of the work. If it can be arranged for material to be delivered direct to the site without going through the store yard a further saving in handling will be effected.

64. Application of mass production methods by detailed organization of the work

1. Although in campaigns overseas in countries within reasonable distance of the United Kingdom accommodation will probably consist mainly of standard huts constructed by mass production in the United Kingdom and transported overseas, in many cases such huts may only be available in small quantities, if at all.

2. In these cases the provision of the necessary accommodation will depend on local effort, and the provision in a reasonable time of the large amount required will render imperative the application of mass production methods.

3. A table of constants of labour is given in Appendix V. This table gives the time required for each process in the

construction and erection of the normal hut (Chapter XV and Pl. **30**) by men of average skill.

By ensuring repetition work, the time for each process can be reduced by at least 60 per cent. ; conversely it can as easily be doubled.

4. An analysis of the various processes required in the erection of a living hut (Sec. 77 *et seq.*) gives the following sequence of operations :—

- i. Pegging out on site.
- ii. Excavation of foundation picket holes.
- iii. Fixing of foundation pickets and trueing up.
- iv. Filling in round pickets.
- v. Erection of side frames.
- vi. Fixing of roof trusses, purlins, etc.
- vii. Building in of end framework.
- viii. Covering of roof.
- ix. Construction of floors.
- x. Fixing of doors, windows, stoves, etc.
- xi. Inner linings and ceilings.
- xii. Painting, if any.

5. Subsidiary operations which can take place simultaneously without interference with the above sequence, are :—

- i. Cutting of foundation pickets to length, and tarring.
- ii. Construction of side frames and fixing outer coverings on them.
- iii. Construction of roof trusses.
- iv. Construction of windows and doors, and glazing of windows.

The essential condition is that these subsidiary operations shall be completed in time, so as to give no cause for delay in the sequence of erection operations.

6. A man can normally work for four hours on end without requiring an interval for eating and rest, and it leads to waste of time and confusion if he is moved from one job to another during that period.

Each of the operations in para. 4, above, should therefore be treated on the four-hour basis, and the number of men required to complete it in that time worked out by applying the appropriate labour constant.

Gangs are then formed of the numbers required for each operation, and proceed from hut to hut on the same operation in regular sequence until every hut is completed.

The rest interval can be used to catch up time where it has been lost on any operation.

7. It will be found that some operations, *e.g.* timber flooring to huts, require so many men to complete in four

hours that the resulting congestion would defeat its own object. In such cases a double period or even longer will have to be allowed.

8. If the work is of sufficient magnitude, two or more similar series can be organized, and a healthy spirit of competition set up between the rival gangs.

9. It will be found, however, that any system on these lines will break down badly if the supply of materials is not kept absolutely up to time, and if constant supervision is not exercised.

10. As men become skilled at their particular operation there will be a continual improvement in output on the labour constants, and the strength of gangs will require continual adjustment to keep them in full work during their four-hour periods.

PART III.—CONSTRUCTIONAL DETAILS

CHAPTER XIII

MASS PRODUCTION OF HUTS

65. The amount of hutting required

Should any considerable expansion of the original force in the theatre of war become necessary (*see* Sec. 1, 2), this will necessitate a large amount of hutting in the line of communication area, which can only be provided in time by the adoption of mass production methods.

66. Design governed by means available

1. The standard types adopted at the outset of a war may have to be adhered to throughout a war, as a change to other types complicates manufacture, repairs and the replacement of parts.

2. If the provision of huts in large quantities may be necessary, careful calculation of the probable availability of materials, labour and transport is essential.

Designs must be prepared in accordance with probable supplies, and not in accordance with those desired.

3. It cannot be emphasized too strongly that in war it is useless for an engineer to design any work or structure and then expect to get the requisite materials, labour and transport on indent; on the contrary he must ascertain what materials, labour and transport are available, and design accordingly. The efficiency of the engineer in war lies in his ability to meet requirements with the means available.

67. Materials, labour and transport

1. **Materials :—**

   i. There will not be unlimited supplies of any material which is not usually obtainable either in the theatre of war or in the United Kingdom : and the distance away of the theatre of war will be the governing factor as to what supplies may be expected from the United Kingdom.

   ii. The United Kingdom cannot supply suitable timber in large quantities, whilst supply from other countries, *e.g.* Scandinavia, is by no means assured. The

supply at any one time of wrought timber such as floor-boarding and match-boarding must especially be regarded as strictly limited.

iii. It may reasonably be assumed that the United Kingdom can supply corrugated iron and steel sections in sufficient quantities to meet any demand likely to be made by an army.

iv. Glass substitutes are not normally produced in large quantities in the United Kingdom in peace time, but experience has shown that they can be so produced at short notice.

v. Joinery such as doors and window sashes will be obtainable in the required quantities at short notice, so long as no variations from standard patterns are demanded, and the distance of the theatre of war is not too great.

2. **Labour**—An army which is brought to a standstill requires cover at once; early provision is therefore of much greater importance than quality.

Consequently, facility of erection by unskilled labour is an essential condition.

3. **Transport.**—Transport, especially by sea to a distant theatre of war, and road transport in the theatre itself, will be limited, and will therefore undoubtedly restrict the tonnage which can be transported in a given time to any given camp site.

Consequently huts should not be provided with floors until all have been erected and transportation facilities permit.

The floors of peace-time huts constitute a large percentage of the total weight, and those of the war type Nissen hut half the total weight.

Further, armies will not normally remain for indefinite periods in one locality; and when they move out of temporary camps it is highly desirable that as much as possible of the materials put into them should be removable.

68. Qualifications of an ideal standard hut

An ideal standard hut must, therefore, have the following qualifications:—

i. Be readily removable without damage.

ii. Contain a minimum number of parts.

iii. Be of such simple design that unskilled parties of men under their own N.C.Os. can erect it.

iv. Not depend on its floor for its stability.

v. Be of minimum bulk and weight—*i.e.* no curved members and no part or package to weigh more than 2 cwt.

vi. Be suitable for manufacture from materials readily obtainable in large quantities, and with a minimum of skilled labour.

vii. Be capable of erection with a minimum of motion:

viii. Lend itself to being rendered splinter-proof up to 3 ft. above floor level.

In short, it must be simple, portable, but not easily damaged in transit, and fool-proof.

The " Adams " hut, illustrated on Pl. 22, has been adopted as the standard living hut for an army in an overseas theatre of war.

CHAPTER XIV

HUT CONSTRUCTION

69. Design

1. Whatever may be the supply of standard huts from the United Kingdom, in every theatre of war, some huts, and in a more distant one, the bulk of the huts, will have to be constructed locally. Squared timber and corrugated iron are to be found in most civilized countries, and they are the simplest and quickest materials to build with and the most easily transported. Other types may have to be adopted, however, under special conditions, and this chapter contains a brief description of the various materials which may be used under varying conditions.

2. Before suitable designs can be prepared, the following factors must be considered :—

i. The purpose for which the accommodation is required.
ii. The material available.
iii. The labour available.
iv. The transport available.
v. Climatic conditions, duration of occupancy, etc.

Simplicity in design will save time, labour and materials, and facilitate the rapid construction and erection of huts.

3. In a theatre of war economy of material is of vital importance ; consequently factors of safety must be reduced to a minimum, even if it may result in a few huts failing to resist some exceptional storm. Any dimensions given in type designs may be reduced to conform to calculations based on the data given below :—

i. In European countries it will suffice to allow for a maximum pressure on roofs of 10 lb. per square ft.
ii. The safe working stress for common Baltic fir may be taken at 1,500 lb. per square in.
iii. Floor joists can be spaced at 18-in. centres for 1-in. flooring.
iv. The proportion of depth to unsupported length for timber joists may be as low as 1 to 30.
v. Concrete floors may normally not exceed 3 in. thick, and the cement to aggregate proportion 1 to 8.

70. Spans

1. Much time and labour is saved by having as few different spans as possible, and in any large hutting scheme three or four different spans should meet all requirements.

The following table indicates useful spans for various types of building.

TABLE A.—USEFUL SPANS FOR VARIOUS TYPES OF BUILDING

Span in feet.	Suitable for
10	Lean-tos and verandahs (hospital wards in tropical climates).
12	Cooking shelters, latrines, ablution places, and stables (single row).
16	Sleeping huts, stores, small blocks of officers' quarters, etc.
20	Cookhouses, unit offices and stores, hospital wards in temperate climates, etc.
24	Stables (double row), forges, stores, hospital wards in tropical climates, etc.
28	Cookhouses, dining huts, stores, recreation rooms, double blocks of officers' quarters, large office blocks, small workshops, etc.
36	Depot store sheds, workshops, etc.

NOTE.—With steel-framed buildings these spans are slightly modified to fit the standard steel members adopted, *see* Appendix IV.

Spans of over 28 ft. should be confined to workshops, large depot store buildings, and other buildings required for special purposes.

2. The spans having been decided upon, type designs of buildings should be adopted. Pls. **22–25**, **30** and **56** show suitable designs for spans from 16 ft. up to 36 ft.

3. In addition to supporting the weight of the roof, trusses have an important function in keeping the structure rigid and preventing the walls from splaying. Knee bracing is usually necessary to give transverse stability.

71. Timber

1. As timber will be available to some extent in almost every possible theatre of war it is desirable to give a few particulars for guidance in its selection.

Yellow deal is the most suitable for general purposes, and third quality or inferior is good enough in all ordinary cases.

2. **Scantlings.**—It is essential to use stock scantlings. At home, market forms consist of the following, in lengths up to 23 ft.

i. Planks—11 in.–18 in. wide by $3\frac{1}{4}$ in.–$4\frac{1}{2}$ in. thick.
ii. Deals—9 in. wide by $2\frac{1}{4}$ in.–4 in. thick.
iii. Battens—5 in.–7 in. wide by $1\frac{3}{4}$ in.–$2\frac{3}{4}$ in. thick.
iv. Flooring (with prepared edges)—$\frac{3}{4}$ in.–1 in.–$1\frac{1}{4}$ in.–$1\frac{1}{2}$ in. thick by $4\frac{1}{2}$ in., $5\frac{1}{2}$ in. and 6 in. wide.
v. Match-boarding—1 in.–$\frac{7}{8}$ in.–$\frac{3}{4}$ in.–$\frac{5}{8}$ in.–$\frac{1}{2}$ in.–$\frac{3}{8}$ in. thick.

Abroad, markets may be restricted to particular sizes, of which the 9-in. by 3-in. deal is the most common, and lends itself to ready conversion into 6-in. by 3-in.–4-in. by 3-in.–3-in. by 3-in., and other useful scantlings.

A saw-cut wastes about $\frac{1}{8}$ in. thickness.

Larger scantlings can always be built up by 2, 3 or 4 ply-work where necessary.

3. In specifying timber for hutting, it is sufficient to enforce the following points only :—

i. The scantling should be exact to measurement.
ii. The timber should be free from twists and warping.
iii. It should have fair edges, arrises and ends.
iv. The ends should not be split or damaged.
v. The timber should be free from rot, sapwood, large, loose or dead knots and shakes.
vi. It should have fairly good straight fibres along the length of the deal.

Baltic timber is usually specified—fifth quality is frequently exported abroad, but is not suitable for hutting of any permanency in climates similar to that of the United Kingdom, and it is better to specify third quality.

All timber should be checked before acceptance.

4. Apart from its use as joists, studding or framing, rafters, purlins, etc., timber in huts is used for :—

i. **Floor-boarding.**—$\frac{7}{8}$ in.–$1\frac{1}{4}$ in. thick, average width 6 in., and either butt-jointed, or, in better-class work, tongued and grooved or rebated and filleted.

ii. **Inner linings and ceilings.**—(*a*) in the form of **match-boarding** $\frac{3}{8}$ in.–$\frac{7}{8}$ in. thick, average width $4\frac{1}{2}$ in.; of which the V-joined match-boarding is the best, as it conceals shrinkage. (*b*) in the form of **3-ply wood,** in sheets about $\frac{1}{4}$ in. thick, but this is expensive.

iii. **Outer linings.**—(*a*) in the form of **weather-boarding,** 5 in.–7 in. wide, cut feather-edged ($\frac{1}{4}$ in.–$\frac{3}{4}$ in.) from $1\frac{1}{4}$-in. boarding.

Rebated boarding is the best. It is laid with 1-in.–$1\frac{1}{2}$-in. overlap horizontally, and nailed on to the timber framing.

(*b*) In the form of **plain boarding** which, when laid vertically butt-jointed and with cover fillets, makes quite a good outer lining.

72. Corrugated iron

1. This material is now made from steel sheets, but is still generally known as corrugated iron. It is the most suitable of all covering materials. It is light, strong, easily fixed,

fire-resisting and easy to transport. Its drawbacks are that it is not heat or cold resisting, and is very noisy in storms.

2. It can be either galvanized or black. Galvanizing protects from rust for a considerable time, increases the weight slightly (up to 10 per cent.) and reduces the strength a little. This reduction of strength is immaterial in most cases.

Galvanized sheets do not take paint well, and for camps which are to be up for some time it is usually better to use black sheets and paint. This is especially the case where camouflage is required for concealment from the air.

In dry climates, however, galvanizing will last for many years.

Before galvanized iron is painted a coat of mordant should be applied.

3. Sheets are obtainable in lengths from 3 ft. to 12 ft., varying by 6 ins.; 6-ft. and 9-ft. sheets are the most common, 7-ft. 6-in. and 10-ft. are also found in many markets abroad. Sheets of other sizes are unlikely to be available in any quantity.

The thickness varies from 28 gauge (·0148 in.) to 16 gauge (·064 in.).

For permanent work 18 to 20 gauge sheets are used, but for temporary work or on active service 22 to 24 gauge is good enough. 26 gauge can be bent in the fingers, and is seldom suitable.

4. The width of the sheets is about 26 in., and the corrugations have either a 3-in. or 5-in. pitch. The 3-in. is more common, and stronger, and should always be used where possible.

5. Corrugated iron is made up in bundles of about 80 ft. run, and weighing 2 cwt. Bundles are fastened with strips of tarred felt and hoop-iron bands. The latter are of great use in hut construction (Sec. **79**, 3, and **80**, 5). The tar from the tarred felt should be scraped off the sheets to be painted, as it sweats through paint.

6. **Overlaps.**—Lengthwise 6 in. to 12 in. according to exposure to wind. Sideways $1\frac{1}{2}$ corrugations.

The overlapping sheet must finish on a ridge, not a valley, and the overlap should be away from the direction of the prevailing wind.

The effective covering value of a sheet is about 20 to 21 in.

A quick method of estimating the number of sheets required to cover any given length is to divide the total length in feet by 2 and add $\frac{1}{6}$th, which gives the approximate number of sheets required.

7. Any given area can be covered more quickly with large sheets than with small ones, and there is then less waste on overlaps.

Cutting should be avoided where possible, as it is slow and laborious.

Sheets can be cut with special apparatus, or with a hand axe or cold chisel, and jagged edges can easily be hammered over.

73. Fixing of corrugated iron (Pl. 29)

1. The sheets are fastened with galvanized steel drive screws and washers.

Holes are first punched in the sheet, and the screws then driven into the wood below by hammer.

To remove, two or three turns are given with a screw-driver, and the screws then prized out.

2. Screws are fixed on the ridges at every side lap, and about every third corrugation.

Two rows of screws are required for sheets up to 5 ft. in length, and a third row for larger sizes.

In strong winds, hoop-iron can be run over the sheets for additional security.

3. Washers are either steel domed or lead; the former fit the corrugations well and make a water-tight joint; the latter are expensive.

4. In cases of necessity French nails can be used, and will hold for a short time.

74. Other materials used in hutting

1. In certain cases it may be necessary to use materials other than wood or corrugated iron in hut construction.

2. **For frameworks.**—As an alternative to timber, steel sections or brick or stone piers, etc.

3. **For walls.**—Expanded metal covered with mud, lime or cement plaster, set as panels between the framing.

In no case should the plaster be less than 2 in. thick.

Concrete blocks.

Sun-dried bricks.—The manufacture of sun-dried bricks and concrete blocks is dealt with in Chapter XXVII, and the construction of sun-dried brick huts in Chapter XVI.

Pisé-de-terre.—The construction of *pisé-de-terre* walls is dealt with in Chapter XVI.

4. **For linings.**—Composition boardings, of which there are many proprietary types on the market. Stout canvas (preferably hessian), cardboard, etc.

Practically all require cover fillets at the joints.

5. **For roof coverings.**—Tarred or bituminous felt, laid on close boarding.

Asbestos cement slates.

Shingles—*i.e.* wooden tiles of hardwood, split (not sawn) and laid like slates.

75. Fire resistance

It will be observed that some of these materials such as corrugated iron, asbestos sheets, etc., are fire-proof; but normally, owing to the large amount of timber in a hut, it is seldom possible to save one once it is alight, and all that can be done is to try to confine the fire to the one hut.

Fires can be localized by having spare sheets of corrugated iron (12-ft., if possible) available to lay against the sides of a burning hut; or by providing portable corrugated iron screens to place round it.

CHAPTER XV

TIMBER AND CORRUGATED IRON HUT

76. The siting of the hut

1. As far as is compatible with the general lay-out and the considerations of aspect and prospect, huts should be aligned along contours rather than across them.

This will greatly reduce the lengths of foundation pickets and the amount of work required where solid floors are provided.

2. Where time and labour permit, it is desirable to remove any vegetation and the top few inches of soil from the actual site of the hut.

Otherwise the vegetation will become rank, and the hut will always be damp.

Where solid floors are provided, it is essential that the top spit should be removed. (*See also* Sec. **82**.)

77. Foundations

1. Wooden pickets, or brick, concrete or stone pillars are usually the most economical forms of foundation for a hut.

Where wooden pickets are used, both ends should be cut off square. Holes should be formed to take them, either by jumping with a crowbar or with an earth auger.

In soft ground it will be necessary to excavate the holes and to place sole plates under the pickets. These will normally be about 1 ft. square. Pointed pickets driven in with a maul will always sink sooner or later, and should never be used.

Pickets must be spaced and aligned accurately, and, after fixing, their ends should be cut off square to the required level.

2. An approximate method of determining the spacing of pickets is to take the square root of the sectional area of a picket in inches, and this will give the necessary spacing of the pickets in feet.

In no case should pickets be more than 6 ft. apart, and a picket should be placed under each stud which carries a truss.

Where, owing to the unevenness of the ground, pickets stand more than 2 ft. 6 in. out of the ground, they should be crossed-braced.

3. Wooden floors can be supported on pickets in the same way as the framework. There should be an air space of at least 9 in. between the floor and the surface of the ground.

4. Wherever possible foundation pickets should be tarred to a height of 9 in. above the ground.

5. On dry, hard, level sites, pillars or pickets may sometimes be dispensed with, and the studs of the framework are then prolonged into the ground and rest on sole-plates.

78. The framework

1. The sides of timber huts are formed of a framework of scantlings covered with some suitable material, of which corrugated iron, sheets and weather-boarding are the most usual.

2. The framework consists of vertical members known as studs or styles, and horizontal members, of which the top and bottom members are called sills and plates, and intermediate members rails or stringers.

3. The plates and sills are first assembled, and the studs are then inserted at appropriate intervals. Studs are provided under each truss, and intermediate studs as required for the framing of doors and windows.

4. Where the sides of the huts exceed 8 ft. in height a middle rail is required, and is fitted in short lengths between the studs.

In any case intermediate rails are required for the framing of windows and doors.

5. The plates and sills will require jointing in huts of any length. Bottom plate joints should be halved and always be placed over foundation pickets.

Top sill joints are scarfed, and should be placed over a stud. All other junctions are butt joints skew nailed (Pl. **30**).

6. With huts of considerable length, to keep the huts rigid, diagonal bracing is required at the end bays and also at intervals of 50 ft.

7. The corrugated-iron coverings should be fixed on the side frames before erection. This not only gives stability to the framework, but saves time in the subsequent erection.

79. Erection

1. The construction of the roof trusses should proceed simultaneously with that of the side frames. They are best built up on one or more templates in a workshop adjacent to the site.

Side frames are best put together at the site of the hut, one on either side, so as to limit the amount of movement and handling.

When the frames are completed, the positions of the trusses should be marked on the top rail; cleats should also be fixed on the trusses to show the positions of the purlins.

2. Erection should not take place until all the parts are ready. The ends can be either framed separately before erection, or built in after erection of the side frames, as convenient; but apart from this, it is important that the sides and roof trusses should be completed before any erection is begun, and the whole of the framework should, if possible, be erected in one day, in order to minimize the risk of damage by storm, as an uncompleted framework has very little stability.

3. When all the preparatory work has been completed, the sides and ends of the framework can be lifted into an upright position and placed on their foundations. This operation can be assisted by using temporary struts nailed on the framework at eaves level; these struts will also help to support the sides and ends while they are being fixed together.

As soon as the framework has been fixed in position, it is secured to the foundations either by nailing to wooden pickets or by fixing hoop-iron straps set in the brick or stone pillars.

Where wooden pickets are used, additional fastenings of hoop-iron nailed to the sides of the pickets should be provided at intervals. Angle braces should also be nailed on the top rail at the four corners, so that it will stand without support.

4. As soon as possible after the fixing of the frames, the roof trusses should be lifted into position, secured to the frames, and the purlins fixed.

5. If the framework of a long hut is too heavy or unwieldy to be erected in one operation it should be erected in sections.

80. Roofs

1. **Loads.**—Roofs are designed for small loads only, and the weight of snow or workmen is ignored.

Experience shows that roofs strip rather than fail by pressure.

2. **Pitch.**—A steep pitch gives a good appearance, prevents snow lodging or workmen overcrowding on it, and reduces the danger of stripping in high wind; but it requires more material. The slope varies from $\frac{1}{4}$ to $\frac{2}{3}$; generally $\frac{1}{2}$ is suitable.

3. i. Trusses are the most complicated part of the design, and therefore should be as limited in variety as possible.

ii. Three different spans should be enough for any ordinary camp, and often two will suffice.

iii. The spacing of trusses varies from 2 ft. 6 in. to 15 ft. There are arguments for and against close spacing. The farther apart they are the bigger the load they have to carry.

They must be more substantial, and heavier concentrated loads are brought on to definite points in the side framing, which will then require strengthening at those points.

Similarly, purlins bridge larger spans, and must be more substantial. If they are too close, however, there is waste of material.

iv. For spans up to 18 ft., therefore, the average spacing is about 4 ft., and this is suitable, particularly where ceilings are provided.

v. As spans get larger trusses require to be over studs; and this is essential when king post or other elaborate trusses are used. In extreme cases it is advisable to build trusses and supporting uprights in one piece, framing in the sides between these members.

4. In the field, for huts up to 20 ft. span, the standard type of truss is the collar beam, with knee bracing for spans over 16 ft., or in long huts without internal partitions.

This is illustrated on Pl. **30**.

Alternative designs in steel or timber are given in Pls. **23–25** for standard trusses for huts of wider span.

These can be either manufactured in bulk and transported to the theatre of war, or be made up in base workshops, or in timber on the site of the work.

5. **Purlins.**—These are placed 3–6 ft. apart, according to the roof covering. They are not necessarily regular, but must be spaced so that sheets can be secured at their junctions.

4-in. by 2-in. purlins are suitable for small spans. Where trusses are widely spaced it is advisable to calculate the sizes. Purlins must always be fixed at the top and bottom lines of the roof, and wherever sheets join.

All purlins rest against cleats nailed to the rafters in the requisite positions, but for additional security the lowest purlin should be fixed with hoop-iron to alternate rafters.

6. **Roof coverings.**—Corrugated iron is nailed direct to the purlins.

The ridges are covered with plain galvanized iron ridging in 6-ft. lengths, which is fixed to the top purlin on either side over the roof covering.

The ridging should not be hammered into the corrugations, but packed up with felt, etc., to make a tight joint.

Valleys should not normally be required, but, where they must be provided, inverted ridging is suitable.

Ridge ventilation should be avoided as far as possible, as it involves complicated construction and flashings to make it waterproof.

A suitable type of roof where continuous ridge ventilation is required is illustrated in Pl. **31**.

If other ventilation is required it can be best provided by fixing louvres in the gable ends of the huts.

A large overhang at the eaves improves the appearance of the hut, but the amount must be governed by climatic conditions.

At least 6 in. must be provided to carry the roof drips clear of the sides, as eaves gutters are only provided in exceptional cases.

In the tropics, a 2-ft. overhang is very desirable, to give partial protection from the sun to the sides of the hut.

Where time and conditions justify it, a fascia board greatly improves the appearance.

At the gable ends the purlins can be cut off flush, and the end sheeting carried up over them to meet the roof.

For better class work, the purlins should project from 3 in. to 12 in., and barge boards should be provided.

7. **Eaves gutters.**—These, where provided, can consist of galvanized half-round iron, made on the spot, and supported by brackets fixed on a fascia board. An alternative in the form of two creosoted boards, V-shaped, rebated and screwed in white lead, will also be found suitable.

8. **Coverings other than corrugated iron :—**

   i. Tarred felt on boarding.—Tarred felt is obtainable in lengths 2 ft. wide. It must be laid on close boarding with cover fillets at the joints; it then forms a warm roof, and obviates the necessity for a ceiling.

   ii. Other types, *e.g.* slates and tiles, whether composition or natural, require to be laid on battens in accordance with normal building practice.

9. Roof coverings under tropical conditions are dealt with in Sec. **90**.

81. Walls and openings

1. **The side covering,** if of corrugated iron, is placed outside the studs. The positions of the doors and windows must be considered in relation to the covering power of the sheets available, the iron being fixed with the corrugations vertically.

Coverings must be carried well below the floor line for protection, but must be high enough off the ground to permit

of ventilation and cleaning under the hut, or openings must be left for the purpose. Such openings should be closed with wire netting.

2. **Linings** are required for warmth in corrugated iron huts, although at the start they will normally only be provided in hospital wards and superior huts.

They may consist of a variety of materials, *e.g.* felt, rot-proof canvas, tarred paper, asbestos cement sheets, 3-ply wood, or any one of a variety of proprietary articles.

Wooden cover fillets are required at the corners, at floor and ceiling lines, and in most cases at joints in the material used.

Triangular 2½-in. by 2½-in. or rectangular 2-in. by 1-in. fillets are suitable. Where water is liable to damage the lining, corrugated or plain galvanized iron can be used, and this is also suitable for door linings. Kerosene tins cut up form a suitable substitute.

3. **Windows.**—Standard windows may be available, in which case the framework must be designed accordingly.

They need not be made to open, as the normal construction of a hut permits of ample ventilation. They may be covered with a glass substitute, which can be removed as required in hot weather.

Where standard windows are not available the most suitable type is a double casement about 3 ft. by 3 ft. with a 3 ft. by 1 ft. hopper light above.

The bottom should be at least 3 ft. above the floor level.

The window frame consists of a simple rectangular frame of 1-in. or 1½-in. planed timber, and is secured by being wedged inside the studding, a small ½-in. cover fillet being planted on to cover the junction, to take the place of a rebate in the frame.

If glazed, the glass is secured by brads, and puttied down if possible.

Glass substitutes can be made in the form of :—

i. oiled linen, which is secured by small fillets round the sides of the sashes;

ii. oiled canvas between two plies of wire netting, secured in a similar way;

iii. wire netting of very fine mesh dipped in melted glue, also secured in the same way.

4. **Doors.**—As with windows, so standard doors may be available, in which case the framework is designed to fit the door. When local manufacture has to be resorted to, the following sizes and types will be found generally suitable :—

i. Doors for superior buildings—7 ft. by 3 ft. by 2 in., framed and braced. In messes and hospitals, main doors 7 ft. by 4 ft. by 2 in. hung folding are suitable.

ii. For inferior buildings. For latrines, etc., ledged doors 6 ft. by 3 ft. by 1 in., for other buildings, ledged and braced doors, 7 ft. by 3 ft. by 1 in.

Where there are steps up to a hut, doors should open inwards.

Door frames consist of 1-in. to 1½-in. deal fitted between studs (wedged, if necessary) and rails. Instead of cutting a rebate in the frame, it is simpler to plant a ½-in. fillet on it.

With both doors and windows, the studs themselves can be used as frames, but, as they are unwrought it is usually advisable to fit in a separate wrought lining as a frame.

82. Floors

1. Earth mixed with white ant earth, straw, cinders, or loose planks, may be used temporarily for floors—to be replaced later, and where available, by marquee bottom panel flooring from ordnance store. Such floors can only be used when the site is level and the walls come down to the ground level.

2. Huts intended for long occupation will normally have to be provided with proper floors; the type of floor provided will be governed by the materials available and the purpose for which the huts are required.

3. The most common type of floor is wooden boarding laid on joists, and this will be the normal type except where water is laid on, *e.g.* ablution places, cookhouses, etc., when the floors will be of concrete.

4. Where wooden floors on joists are provided, the joists will normally be of 4-in. by 2-in. deal, spaced at 18-in. centres, and supported on sleeper walls, or plates laid on the foundation pickets, spaced from 4 ft. to 6 ft. apart. The joists should be skew nailed to the sleeper walls or plates.

Except in superior work, where tongued or grooved or rebated and filleted boarding may be used, the floor boarding will be butt jointed; and should therefore be carefully laid to avoid draughts, either with cramps, or folding.

The boards should be nailed close to the edges to lessen shrinkage. 1-in. boarding is sufficient for normal use, and for light wear this can be reduced to ⅞-in.

5. Concrete floors consist normally of 3 in. of 1 to 8 concrete on 3 in. of hard-core.

They should be laid to channel with a kerb at the corners.

The sides of huts can be secured to bolts set in the concrete at intervals of 3 ft. to 4 ft., or foundation pickets can be placed in the usual manner before concreting.

The pickets are then sawn off 3 in. above the finished surface,

the framework fastened on them, and the concrete kerbed up to meet it (Pl. 34).

The concrete should be extended for about 12 in. beyond the sides and ends of the huts.

To save any unnecessary excavation where possible, the most level sites should be selected for huts with concrete or solid floors.

83. Verandahs

Verandahs should only be constructed on buildings for which they are officially authorized; and the width should be specified.

Verandahs require a great deal of material, and, although they may be essential under some conditions, they may often be omitted in the first instance, and added later when more essential services have been completed.

They are required more especially in tropical climates to keep the sun off the main walls of the building, and to give sitting or lying accommodation in hospitals, or as covered passages for orderlies in office buildings.

Scales are given in Appendix II.

For verandah roofs up to 6 ft. wide, planks or corrugated iron sheets without support can be used; greater widths require rafters or purlins.

A verandah usually has a roof lower than that of the main building to permit of clear eaves ventilation to the building. Verandah posts are approximately 4½ in. by 3 in. with the wider side to the front, spaced 6 ft. to 8 ft. apart, and stop chamfered for appearance.

Verandah floors are usually set about 1½ in. lower than the hut floor to keep rain out of the latter, and with a fall outwards of 1 in. to 1½ in.

Open batten floors are cheap and suitable (except for hospital verandahs), but let the dirt get through.

84. Heating

Stoves are normally used for heating huts, and they should be of standard pattern. Huts are usually very inflammable, and great care should therefore be taken in fixing stoves.

Stoves should be kept at least 2 ft. away from any inflammable wall, and should rest on properly constructed floor trays (Pl. 33).

The trays should extend for 12 in. in every direction beyond the edge of the stove, and should be surrounded by a raised kerb. The trays can consist of sheet iron over asbestos millboard, or of concrete or stone, with bent sheet iron kerbs.

The flues are best taken up through the roof, but this

involves considerable work to make the hole watertight; and if the hut is ceiled it is usual to carry the flue through the side.

Simple methods of taking flues through the roof and side are also illustrated on Pl. 33.

The flues must be kept at least 4 in. away from any woodwork.

In more important and permanent buildings, brick fireplaces may sometimes be provided. Pl. 34 illustrates some simple types.

85. Finishings, ornamentation and painting

1. **Finishings.**—Where circumstances justify it, the comfort, appearance and amenities of a hut can be greatly improved by a few simple finishings. Thus, architraves can be used round doors, windows, ventilators, etc. Ready-made mouldings are best, but double chamfered $2\frac{1}{2}$-in. by $\frac{3}{4}$-in. fillets are suitable. Flashings above door and window openings are also a great improvement. Plain galvanized iron inserted 3 in. under the outer covering, and then bent forward, is adequate.

Where verandahs are provided, rails and balusters improve the appearance.

2. **Ornamentation.**—This cannot be used much except perhaps in permanent peace hutted camps; but with a little care and trouble, good effects can be obtained at a very small cost.

i. Lines of huts can be broken up by the more important buildings, and ornamentation concentrated on a few outstanding ones by such means as steeper pitches to roofs, good overhang to eaves, ornamental but simple fascias, barge boards, finials, etc.

Other simple instances are :—

ii. Verandahs—the provision of ornate brackets, posts, balusters, etc.

iii. Main entrances to important buildings—the provision of pediments over the door with barge board and finial.

iv. Ventilators and louvres of good design and appearance.

v. Steps into huts—variation in length or the provision of hand-rails.

3. **Painting.**

i. All woodwork in connection with the ground, and the external woodwork of huts should be treated when quite dry with solignum, creosote, or other preservative.

ii. Doors, windows and exposed iron-work should be painted three coats including the priming coat, both internally and externally.

iii. Linings are painted, or oiled and varnished as required. Generally, dark colours are best up to the dado line at window sill level. Above, lighter colours can be used. Paintwork may be varnished after the second coat instead of painting four coats of paint, but this is not suitable in hospitals, where considerable glare may be reflected off the coat of varnish.

iv. It is not usual to paint galvanized iron, but it may be necessary for camouflage purposes.

In such cases a mordant is necessary, and paint with a zinc base containing carbon bisulphide, or a coat of distemper, is suitable.

v. In tropical climates external limewashing has considerable effect in cooling the interior of a building; and it has the advantage of being relatively cheap.

To make it adhere properly, add 12 lb. of salt and 1 gal. of boiled linseed oil to half a barrel of lime, and fill up with water.

Limewashing is also satisfactory for interior work, and is cheap and hygienic.

86. Materials required for a 60-ft. by 16-ft. hut

The detail design for a 60-ft. by 16-ft. timber and corrugated iron hut is given on Pl. **30**, and a list of the materials for its construction is included on the same plate.

CHAPTER XVI

HUT CONSTRUCTION IN MATERIALS OTHER THAN TIMBER AND CORRUGATED IRON

87. General

The distance of the theatre of war from the United Kingdom and its state of development may be such that supplies of common materials such as timber and corrugated iron may be insufficient to cope with the amount of hutting required.

In such cases, local resources and types of construction will have to be used.

The only materials of any use likely to be available in any large quantities are earth and stone, and in some tropical countries, reeds and rushes.

In forest country where timber exists in large quantities, although log huts may have to be erected in the first instance, it will be found more economical to convert logs into scantlings, weather boarding, etc., and to build huts of the normal pattern.

Construction in stone or burnt brick, whether in mud or other mortar, approximates to peace time practice and requires skilled labour; and is therefore beyond the scope of this book.

Construction in sun-dried brick or in *pisé-de-terre* may, however, be resorted to wherever climatic conditions permit, and is dealt with in Sec. **88** and **89**.

The manufacture of sun-dried bricks is dealt with in Chapter XXVII.

88. Construction in sun-dried bricks

1. Sun-dried bricks will vary in size according to the locality in which they are manufactured. A size frequently met with in the East is approximately 10 in. square by 2 in. in depth, but normally it is advisable to adhere to the local pattern.

Where there is no local pattern sizes approximating to that of the English burnt brick, 9 in. by 4½ in. by 3 in., will be found convenient and easy to handle.

2. **Foundations.**—Where possible, it is advisable to lay the foundation courses up to two courses above ground level in burnt brick, but this is not necessary in exceptionally dry sites. In any case, however, foundation trenches must be excavated, and the ground underneath thoroughly compacted,

gravel, broken brick, etc., being rammed in to a firm level.

Stone in mud also forms a suitable foundation.

3. **Walls.**—These are built as in burnt brick, mud mortar being used instead of lime or cement mortar.

In huts of large span, roof trusses require special support either on burnt brick pillars, with panels of sun-dried brick in between, or on posts or stanchions built into the wall.

In smaller huts, the weight on the trusses can be satisfactorily distributed by timber or other wall plates set on the walls.

4. **Door and window jambs, lintels, sills, etc.**—These can be made of burnt brick in clay or lime, or framed in timber.

5. **Mud mortar.**—This should be prepared from stiff clay, which is broken up into a fine powder and freed from grass, stones, etc.

The clay is then mixed with clean water on a clean platform, and worked up to the consistency of clay for brick making.

Before use, the mud mortar should be moistened with water to the required consistency.

6. **Plastering.**—After completion, the walls will be mud plastered and leeped.

i. **Composition.**—Mud plaster is composed of stiff clay to which is added, if required, an equal bulk of chopped straw or pine needles.

In some cases it may be necessary to add sand.

The clay, after excavation, is spread out in the sun and powdered, and the chopped straw or pine needles are added and thoroughly incorporated in the dry state. Water is then added, and the whole left to soak for two days. It is then thoroughly mixed, water being added as required until the consistency of stiff mortar is obtained.

ii. **Application.**—The plaster is spread evenly over the surface to a thickness of from $\frac{1}{4}$ in. to $\frac{3}{4}$ in., as required, and floated off with a straight edge until the surface is properly smooth, true and level.

Any cracks that open up during drying are filled with liquid cowdung.

iii. **Leeping.**—This consists of applying a covering coat of cowdung, clay and, if necessary, sand, applied with a trowel and float.

Leeping is prepared by first steeping the cowdung in water to free it from grass, straw, and other

impurities and, if necessary, passing it through a sieve to exclude seeds. One cubic foot of cowdung is added to every cubic foot of finely powdered clay, and the whole mixed in a tub and thoroughly incorporated.

7. **Weather protection.**—Sun-dried brickwork must be protected from rain until set and dry. It should not be constructed in wet weather.

8. **Roofs.**—These may be of a variety of types, dependent on the materials available locally. Generally, timber in some form or another will form a part of the roof, and if small stocks of corrugated iron are available, these should be reserved for use as roof coverings. In dry climates, mud roofs can be resorted to, but they are very heavy and require such ample support that they would seldom be adopted.

In rainy climates, a good overhang to the eaves is essential to carry the drips clear of the walls, and surface channels are also necessary to carry the water away from the foundations.

9. **Floors.**—Floors of sun-dried brick huts will normally be of earth, with or without a top covering of timber, burnt brick, stone, tiles or other material.

Earth flooring should consist of loam or clay; sandy soil or ordinary mould are unsuitable. If the earth is fresh and damp, no water should be used, otherwise a little should be sprinkled on by hand.

The less water used the better the floor will be.

The earth should be thoroughly consolidated in 6-in. layers, until very little mark can be made on it with the heel of a boot, and should be carried up to a height of not less than 6 in. above the ground level.

In case of renewal, the whole of the old earth should be dug up and removed, before any new earth is put in.

Devonshire barn flooring is an improvement on the ordinary rammed earth flooring, and is made by topping the rammed earth floor with a surfacing 3 in. to 6 in. thick of earth mixed with lime. The clay or other suitable soil should be finely powdered and mixed with lime in the proportion of 5 lb. of lime to 1 c. ft. of earth.

Water is then added in sufficient quantity to make a thick paste. The mixture is laid to the required depth and beaten, being kept moist till the lime has set.

This class of floor is only successful with certain soils, the suitability of which must be determined by experiment.

10. **Lime-washing.**—If possible, sun-dried brick huts for occupation by other than native personnel should be lime-washed internally.

89. Construction in pisé-de-terre

1. *Pisé-de-terre* differs from sun-dried brick in that the mud walls are built between shutters instead of from moulded and pre-dried bricks. It forms an easily and quickly built and substantial form of walling, suitable for small buildings constructed on a large scale, where suitable earth is obtainable, and climatic conditions are suitable for mud walling.

2. i. The most suitable earth to use should ram well and firmly, and not shrink excessively on drying; pure clay is therefore unsuitable. Top or vegetable soils are also unsuitable. Good brick earth of a sandy, clayey nature is best; and a small admixture of stone or gravel is not a disadvantage.

ii. The moistness of the earth is very important; the amount of water present should not be more than 7 to 14 per cent. of the weight of the dried earth.

iii. If the earth is too wet, it will shrink excessively and crack. As long as the rammer consolidates without pulverizing, the material is damp enough.

With the proper dampness, shrinkage should not exceed 2½ per cent. of its dimension, and can generally be kept under 2 per cent.

3. **Shuttering.**—A suitable form of shuttering is illustrated in Pl. **35.**

Separate sets of ties are necessary for different thicknesses of wall.

The holes left by the withdrawal of the tie-bars are filled by syringing in cement and sand.

The inside of the shutters must be well smoothed, and they must be kept continually in gauge.

4. **Rammers.**—A V-shaped rammer (Pl. **35,** No. 1) is used to beat down the earth, and a flat bottomed rammer (No. 2) to surface it. The workmen must not keep time in ramming, as this causes vibration, which is injurious to the stability of the wall.

5. **Construction.**—The number of sets of shuttering required depends on the magnitude of the work and the progress desired.

A set of shuttering is erected, great care being taken that the sides are vertical, and rammed full in 4-in. or 5-in. layers.

The shuttering is then moved about 8 ft. along the wall, and the filling and ramming continued.

It is advisable to leave the shuttering up for one night to allow the earth to become detached from the sides.

Old work should be slightly moistened before new work is joined to it; and it is not advisable to allow a course to dry

thoroughly, as the next course will not knit well into it, and will probably show a crack. If the earth is well rammed, and only the proper moisture admitted, a second course can be begun at once.

All *pisé* wall work must be protected from the rain, and should not be done in wet weather.

6. **Rendering.**—The following external finishings can be used:—

i. 1 sand and 1 ground lime, brushed on.
ii. 1 sand and 1 chalk lime, brushed on.
iii. 1 sand and 1 cement, brushed on.

Internal walls should be plastered two coats, or brushed with a rendering of 1 sand to 1 chalk or ground lime.

7. A suitable thickness of wall for huts of normal height is 14 in.

8. **Foundations.**—These are of the usual type of brick, stone or concrete, and should be brought 9 in. to 1 ft. above ground level. Damp courses are necessary except in dry climates.

9. **Lintels, sills, etc.**—Lintels are made of 4-in. by 2-in. timber placed side by side for the full thickness of the wall (being temporarily supported from the sill during construction) and with a 12-in. bearing on the wall.

3-in. concrete or brick sills for the full thickness of the wall can be used.

The door and window frames should be built in, and must be temporarily braced to stand the ramming.

The eaves should have a good projection to keep drips from the surface of the wall.

90. Tropical construction

1. Sun, heat, flies and mosquitoes are the principal dangers to be guarded against.

2. **Roofs.**—Clean galvanized iron forms one of the best roofs in the tropics, as it reflects away radiant heat, but, wherever possible, it should be combined with a ceiling giving a good air space between it and the roof.

The packing of the air space with some non-conducting material, such as grass or reeds, will help considerably, and in such cases the ceiling is most efficient if made of another radiant heat reflector such as flattened biscuit tins.

Where black corrugated iron or other types of roof are fixed, treatment with a protective pigment gives good results, as these reflect radiant heat to some extent.

White paint gives the best results, but ordinary lime washing is almost as good, and is far cheaper.

In some cases it may be simpler to place a layer of native

mats over the existing roof. In such cases the mats should give a clearance of at least 1 ft., and can be secured to a very light framework fixed on the roof.

3. **Walls.**—Walls require almost as much consideration as roofs.

The chief point to be observed is to have as little sun as possible shining directly on to them. This is achieved :—

i. by the proper orientation of the hut, *i.e.* the sides facing north and south, so that only the ends are exposed to the sun when comparatively low down on the horizon ;

ii. by providing a verandah on the south side, or in special cases on both north and south sides ;

iii. by having a good eaves projection.

Of these i. and iii. can always be arranged, but ii. will seldom be possible, except with hospital wards and perhaps headquarters' offices, messes, etc.

In many tropical countries reeds and rushes are to be found in profusion, and native mats are manufactured in abundance.

In such cases the walls of huts can frequently be formed of these mats, or of the reeds or rushes.

Huts built of these will be hot in the middle of the day, but will cool down very rapidly at night, and will allow of the free passage of any cooling breeze.

Huts built of mud bricks or *pisé-de-terre* should have ample openings for ventilation, which can be kept closed during the day, but can be thrown open at night to permit of free access of the cooler night air.

4. **Precautions against mosquitoes.**—It will usually be impossible to provide complete protection against mosquitoes.

The mosquito proofing of a hut is expensive, and requires a large quantity of material. At the best it will only be possible to proof the hutted wards of hospitals, and perhaps of a few of the more important buildings.

In such cases all doors and windows are hung to open inwards.

Additional doors of mosquito-proof wire are fixed opening outwards, and the window and ventilation openings are closed on the outside with mosquito-proof wire.

In men's sleeping huts it may be possible to issue mosquito nets as an article of equipment ; but in most cases all that can be done is to provide a small square of mosquito netting to each individual, which he can use to cover his face and shoulders when lying down.

5. **Precautions against flies.**—All that can be done in this respect is to prevent the access of flies to latrines, etc., and to food ; the methods to be adopted have already been described in Secs. **54** and **55**.

CHAPTER XVII

ACCESSORIES

91. Latrines

1. Where deep trench latrines are used 5 yards run of trench should be provided for every 100 men.

Weather-proof cover should be provided.

2. As it will be necessary to dig fresh latrines periodically, the shelters and seats should be portable.

3. Pls. **36–38** show types of portable latrines, and Pl. **39** shows a squatter type for native troops. Pl. **40** shows types of urinals.

If none of these is suitable, satisfactory designs should be evolved to meet local conditions and the materials available, the parts being manufactured, if possible, in bulk at central workshops for erection on the site.

92. Incinerators

1. Pl. **41** shows three types of open incinerators.

Dry materials should always be used to start the fire. All air inlets except the one towards the prevailing wind should be kept blocked. Where fire bars are unobtainable the central cairn is provided to improve the draught.

2. The Horsfall and similar commercial types of incinerators, which consume the objectionable gases of combustion, may be used in large camps. A forced draught is employed in some of the larger incinerators, which enables combustion to take place at very high temperatures.

This ensures rapid and complete incineration, and produces a hard and innocuous clinker, which is suitable for making paths and roads.

Incinerators of this type should be installed in a shelter with a concrete floor, and covered storage accommodation should be provided for the refuse awaiting incineration, to keep it dry.

3. It is sometimes desirable to instal water tanks on or at the sites of incinerators, to provide hot water for cleaning buckets: it cannot, however, be considered as a satisfactory supply for other purposes as it is somewhat intermittent, and incinerators are not usually sited near huts where hot water is used.

When tanks are installed, the draw-offs should be at a sufficiently high level to prevent the tanks from being emptied and damaged.

4. Pl. **42** shows types of closed incinerators, and Pl. **43** a closed incinerator with a baffle wall.

93. Ablution places and bath-houses

1. The drainage of ablution places and bath-houses is the most important consideration. If possible they should be provided with concrete floors, and ample arrangements should be made for the disposal of waste water.

2. It will usually be more convenient to provide a centrally-situated bath-house, and separate company ablution places. Hot water should be provided in the bath-house.

i. Pl. **46**, Fig. 2, shows an improvised arrangement that has proved successful. Forty shower baths are provided, sufficient for 800 men a day. There are hot and cold water tanks, each 400 gals., open, and on the same level. They and all piping are lagged with tarred roofing felt. The heater consists of four parallel 2-in. pipes joined together with tees at both ends, and laid in a trench, similar to that of a field kitchen, at a slope of 1/22. Brick baffle walls are built to direct the fire up and down over the pipes. The fuel is either wood or coal, about 1½ to 2 cwt. being used daily.

ii. The circulation system consists of primary and secondary circuits, the draw-offs being connected only to the latter. The cold water enters the system in the primary return, and a siphon is arranged between the cold water tank and the primary return to prevent hot water reaching the cold tank.

iii. An important feature is the non-return valve close to the hot water tank on the primary return. This is to prevent the hot water tank being flooded with cold water if there is a sudden large draw-off for baths. It is very easily made with materials that are likely to be obtainable almost anywhere. In its normal position it is open, as shown in the drawing, but, when the hot water is drawn off, the rush of cold water into the pipe close at hand, closes the valve and keeps it shut until the system is balanced again. In practice it has proved very sensitive and efficient.

iv. The baths are fitted with showers which, if of the pattern drawn, are easily made by tinsmiths. The drawings show two alternative methods for fixing the hot and cold water for each group of five showers. The method shown on the right is recommended, as it enables a man to mix hot and cold water to his liking. In the other, the cold water introduced serves five showers.

v. The arrangement illustrated on Pl. **47** shows a small bath-house for officers or one company. Either, pipes bent hot in a coil, or a combination of bends and sockets (as illustrated), or even a single length of 1-in. or 1½-in. pipe, can be used for the boiler. The coils can be laid either vertically or horizontally. The circuits will be on the same principle as in the larger system.

vi. For extensive operations, standardized portable hot water heaters should be provided from home for field bath-houses.

vii. Adjacent steam boilers used for driving power plant can sometimes be made use of for supplying hot water.

viii. The Benn or similar patent economic shower bath sprayer, if procurable, effects a great saving in water consumption, using only 3 gals. for each bath in place of 10 gals. required with the apparatus described above.

3. Pl. **45** shows suitable types of ablution bench. 12 ft. run of such benches should be allowed for every 100 men.

Pl. **13**, Fig. 1, shows an ablution shed suitable for 250 men. It is provided with two benches, each 15 ft. long, a portable boiler and a Portland cement concrete floor.

94. Cleansing stations

1. Pl. 46, Fig. 1, shows a typical arrangement for a cleansing station, and is the system which should be generally adopted; it provides for both bathing and disinfection (Sec. **97**).

The hot water is provided by a mobile plant, which is supplied, connected up and worked by the R.A.O.C.

2. A suitable shelter will be provided by the engineers, which should contain undressing and dressing rooms, dirty and clean underclothing stores, bath-room and accommodation for the mobile plant, which should be easy of access. The accommodation must be so arranged as to facilitate the loading from the undressing room and unloading to the dressing room of the clothing to be dealt with by the disinfector.

Five times as much dressing space should be allowed as bathing space, *i.e.* on the assumption that each man takes 2½ minutes to bathe and 12½ to dress and undress.

95. Cookhouses

1. Weather-proof cover should be provided for cooks to enable them to prepare food properly. For temporary camps shelters of 3-in. by 2-in. scantling and corrugated iron can be rapidly improvised (Pl. **19**).

As soon as possible, in all camps to be occupied for any length of time, concrete floors should be provided.

2. In semi-permanent camps, proper cookhouses should be provided. Pl. **14**, Figs. 1 to 5, shows cookhouse plans for various strengths.

3. Ridge ventilation is an essential, and in warm climates cookhouses can be left open at the eaves as well, although close mesh wire netting must then be provided to keep out flies.

4. Linings should not be provided, but the interiors should be limewashed at frequent intervals.

5. Hospital cookhouses require more space than unit ones, owing to the variety of diets to be prepared.

6. **Cooking arrangements.**—To begin with, troops will use field cookers, etc., but in camps of a more or less permanent nature, fixed cooking arrangements should be substituted.

Suitable types of oven and cooker are shown in the Manual of Field Engineering, Vol. II (R.E.).

i. In standing camps, cooking ranges should be provided. These vary in size from the 72-in. two-oven type to about 24-in., and they require to be supplemented by boiling units; either Soyers stoves, Farm boilers, or other types.

An infantry battalion would require 5 72-in. ranges and 4 boilers.

ii. In some theatres of war, oil cooking may have to be resorted to. Simple types of oil-fired cookers are illustrated on Pl. **44**.

7. Fly-proof meat stores or safes are necessary, especially in hot climates. At least one side should be of wire gauze. Muslin or mosquito netting should not be used.

Joints are suspended from hooks along the top.

8. All shelving and cupboards for storing food should be lined with galvanized iron or zinc. Food bins should be similarly lined, and have ventilating panels of perforated zinc, or wire gauze in the top and front.

9. Where possible, separate lock-up ration stores should be provided. These should be cool, well ventilated and fly- and rat-proof.

96. Grease traps

1. **Grease traps** should always be provided where greasy or soapy water flows into surface drains. The outlets from the sink, etc., should be so arranged that the water splashes into a receptacle containing grass, bracken, straw, etc., through which the water filters, and is then discharged into the drain. If the water is distributed evenly over the filtering material it will percolate through slowly, and the grease will be retained.

2. One square foot of grease trap will normally deal with 200 to 400 gals. of greasy water daily.

3. Grease traps should be cleaned out by the troops daily, the filtering medium being renewed, and should be designed to be fool-proof, as they will be maintained by unskilled men.

4. With cookhouse waste, the grease will be deposited as the water cools, provided there is sufficient volume in the interceptor and suitable baffles are provided.

With soapy water, a precipitant such as alumina ferric should be used, as the soap will not precipitate with the cooling of the water.

5. Some useful types of grease traps and grease interceptors are given on Pls. **48-50.**

97. Drying sheds

1. A shed or room suitable for drying clothes, etc., should be—

i. reasonably fire-proof;
ii. provided with one or more stoves, according to its size;
iii. provided with rails, racks or hooks on which to lay or hang the garments.

Careful precautions against an outbreak of fire will always be necessary.

Pl. **13**, Fig. 3, shows a drying room suitable for 1,000 men.

2. A wire-netting beehive frame, 5 ft. or 6 ft. high, and the same in diameter, placed over a charcoal brazier is suitable for 10 to 15 men.

3. Pl. **51** shows an improvised drying room arranged in the form of a tower. It is capable of drying 124 overcoats and 32 jackets at the same time.

98. Disinfection

1. **Disinfectors** are sterilizing appliances for killing disease germs in clothing, etc.; they also destroy vermin and their nits.

The disinfecting chambers may be mounted on wheels, or they may be in the form of a sack, barrel or other contrivance for carriage in a transport vehicle or on a pack animal.

They should, if possible, be installed under cover, and may sometimes be very conveniently combined with the mobile bathing plant supplied by the R.A.O.C. (Sec. **94** and Pl. **46**).

Pl. **52** shows the construction of an improvised steam disinfector, which is light, rapidly constructed and convenient to work. It is suitable for installation in all camps accommodating less than 2,000 men.

2. **Disinfestors** are used for freeing clothing and bedding from vermin and their nits, but they cannot be relied upon to destroy disease germs. They take the form of improvised hot-air chambers. Any steam disinfector will, however, also act as a disinfestor.

A type of disinfestor which proved efficient during the Great War is shown on Pls. **53** and **54**, and is known as the Canadian pattern; it will disinfest the service dress (three articles) of 1,000 men a day. The principle of this disinfestor is the treatment of clothes with hot air. It consists of braziers placed in a pit dug in the ground, the hot air ascending through a perforated iron floor into a chamber above. A trolley containing clothing is wheeled into the chamber and left for 20 minutes.

The fumes from coke braziers are dangerous, and hot-air disinfestors should, therefore, not be installed inside bath-houses or other huts where men congregate.

99. Horse standings

1. The provision of satisfactory floors for horse standings and stables often presents difficulties, mainly on account of the lack of suitable materials.

2. The provision of horse standings which can be constructed by unskilled labour should be undertaken by the troops under engineer supervision. The engineers will provide such materials as are procurable but not available locally.

3. **Temporary horse standings** can be constructed of :—

i. **Cinders, slag, chalk or macadam.**—All such standings should be well rammed or rolled to produce solidity and a fair surface. They require attention, as holes are very liable to form in them.

ii. **Logs.**—An even surface is obtained by filling in the crevices with some fairly hard material.

4. For **stables**, a good floor should fulfil the following conditions :—

i. It should be dry. If it is constructed of material of an impervious nature, it should be well drained.

ii. The surface should be sufficiently hard to prevent holes being formed in it by horses' hoofs.

iii. The surface should not be slippery, nor should it be rough enough to cause abrasions on a horse when it lies down. Sharp stones of metalled standings are liable to be displaced and cause injury to a horse.

5. **Types of materials** which may be used in stable floors are as follows :—

i. **Concrete** makes a good floor, but the surface is usually slippery and may, consequently, have to be covered with ashes or sand. It should be given a surface layer of chips and cement in the proportion of 2 to 1 ; otherwise it will not stand the pounding of horses' hoofs.

ii. **Tarred wooden blocks,** laid with the grain vertical, run in with pitch or cement grout, and bedded in sand, make a good floor.

iii. **Blue Staffordshire bricks** make a good floor, but are very expensive. Other varieties of bricks are usually too soft, and require too frequent renewal to be satisfactory.

iv. **Sleepers** make a fairly satisfactory floor, if of sound quality. Only unserviceable ones are, however, usually obtainable, and these soon deteriorate.

v. **Hand-packed soling stone,** with the projections knocked off with a hammer, laid in sand, and run in with cement grouting, makes an excellent resisting floor and is not so slippery as concrete.

vi. **Beech slabs** make a good floor, but they are difficult to fix securely, and their surface is slippery and requires to be covered with a thin layer of ashes or sand.

vii. **Blocks sawn from pit props,** of various sizes and laid in sand, make a satisfactory floor.

viii. **Small round river boulders,** from 4 to 6 in. in diameter, hand packed on a rammed foundation, make a good floor. If they are cement grouted up to about 1 in. from the surface they will be impervious and lasting.

ix. **Tarmac** makes a good floor.

Floors constructed of timber laid in lengths should be laid parallel to the length of the horse.

Floors of sleepers, fir poles and other similar materials allow water to permeate through, and, consequently, the ground underneath them will become foul.

6. In **separate stalls** it should only be necessary to provide special flooring for a width of 4 ft. in the centre and a length of 10 ft., commencing 2 ft. from the head of a stall. The remainder of the floor may be rammed gravel or earth, and level with the special flooring.

100: Stables

(Plate 55)

1. Stables may be required under severe climatic conditions. They should be built with one side open to allow of horses being led to their stalls from an outside gangway.

2. With a small number of horses a 12-ft. span is sufficient; with large numbers it is more economical in material to have a 24- or 28-ft. span with two rows of horses head on.

In this case a solid centre partition is necessary.

3. With large units, 80 to 100 horses should be placed in one stable, but in veterinary hospitals this should be reduced to 50 to lessen the risk of contagion (*see also* Chapter XIX).

4. Each horse requires at least 4 ft. laterally, the stalls being divided by movable bails. Generally bails between each pair of horses are sufficient.

Stables should have a clear height of at least 6 ft. 6 in. at the eaves.

The gable ends of adjacent blocks need not be more than 4 ft. apart, but, if in parallel rows, stables must be at least 12 ft. apart to give room to move horses in and out.

5. Roads should be provided at the ends of the stable blocks, and gangways between stables should be treated in a similar way to the stable floors themselves (Sec. 99).

6. Separate watering troughs are desirable for every pair of stables, and for every stable in veterinary hospitals.

7. Dung pits should be provided at the ends of the stable blocks.

8. **Internal fittings.**—All woodwork inside stables within reach of the horses should be protected by sheet iron or flattened biscuit tins.

Creosoting or tarring gives partial protection only.

Mangers should be easy to clean and disinfect.

2 ft. of manger is required for one horse, or 6 ft. for two horses.

Suitable types can be constructed of plain or corrugated iron rendered with cement, of wood lined with iron or zinc, of concrete, or of mud brick lined with iron or zinc.

Horses are tethered to mangers by rings set in the side of the manger or to a manger rail.

In exposed sites the sides may have to be protected by walls.

4

101. Drains

1. In temporary camps, and sometimes in the first instance in more permanent ones, sullage water must be collected in some form of surface drain quickly and easily provided.

Sheets of corrugated iron, cut into three longitudinal strips, which are bent U-shape and let into the ground with an end overlap of 6 in., form suitable drains, but they are very liable to damage by wheeled traffic, and iron pipes should be inserted where they cross roads.

Grease traps must be provided both where the drains leave buildings and just before they join the soak pits or disposal areas.

2. The best form of surface drain is a shallow cobble drain, which is not liable to damage by wheeled traffic.

If bricks are used, a good form is a bottom of bricks on the flat and two rows, one on each side, lengthwise, sloping upwards and outwards at about 60 degrees to the horizontal. It will not stand wheeled traffic, and culverts to roads are required, or an open section of concrete or cobbles.

3. The capacity of surface drains is governed by the fall. The minimum fall may be taken as that given to sewers, *i.e.* a 6-in. semicircular or V drain should be given a fall of not less than 1 in 60, and a 10-in. one not less than 1 in 100.

A 4-in. drain is the smallest one used in practice, and at a minimum slope of 1 in 40 will dispose of 140 gals. of sullage water a minute.

PART IV.—HOSPITALS, MISCELLANEOUS CAMPS AND DEPOTS

Note.—In dealing with the various depots and establishments which are normally required in the base and other sub-areas of the line of communication area, information has been included regarding the selection of sites, and the considerations governing the lay-outs, and in some cases regarding the method of operating the establishments. The selection of sites is the responsibility of the administrative branches of the staff, in consultation with the various services, while the details of lay-out and operation are primarily the responsibility of the corps or service concerned. The information in question has been included in this manual for convenience, because it is necessary for engineer officers responsible for the construction of accommodation for depots and establishments to possess a general knowledge of their requirements as regards the selection of sites and efficient operation. It should be remembered, however, that the Manual of Movement (War) and the manuals of the corps or service concerned are the guiding authorities on these matters.

CHAPTER XVIII

HOSPITALS

102. General considerations

1. Hospital accommodation may have to be provided by the engineers as under :—

i. **General hospitals.**—These in the theatre of war are located in the base or other sub-areas of the line of communication area. They are unlikely to be moved during the campaign, and their hutting therefore follows exactly the same sequence as that for the Army generally, *i.e.* in a campaign of any duration, hospitals located in the base sub-area would be fully hutted, those elsewhere in the line of communication area being probably only partially hutted.

ii. **Casualty clearing stations.**—These are normally located in the vicinity of ambulance railheads, and are liable to frequent moves; they are therefore normally tented, but during periods of position warfare may require accessories, and possibly in exceptional cases operating theatres, to be hutted.

2. In some cases it may be possible to find suitable buildings which can either be used directly as hospitals, such as existing local hospitals; or which can, with alteration and improvement, be readily made into hospitals, such as asylums, large warehouses, etc. Improvements will usually be necessary, such as the provision of dustless floors, smooth walls and rounded corners, increase of light and ventilation, and the widening of doors to admit stretchers. Extra wards, and operation and administrative blocks will often be required, and these will usually be of the hutted type.

103. Requirements of hutted hospitals

1. **Healthy site.**—The general remarks on the siting of camps (Chapter VIII) are equally applicable to hospitals. Special attention must be paid to the healthiness of the site. Suitable soil is necessary, and it may be necessary to provide a concrete seal over the whole area covered by each hut to avoid pollution of the ground. Good drainage and a full complement of sanitary appliances are essential.

2. **Accessibility.**—The site should be, if possible, close to a railway from which a siding can be laid to it. Good roads are essential.

3. **Sun and air.**—Ward huts should be sited so as to get all the sunshine possible ; a good general rule is to allow 1 acre to 50 ward beds in general, or to 35 ward beds in isolation hospitals.

General ward blocks are normally sited about 25 ft. apart, whilst isolation ward blocks require a clear space of not less than 40 ft. all round each block.

All wards should be well ventilated, but draughts must be avoided; this is best attained by providing regulating ventilators in the walls near the eaves. Cross ventilation should be provided between wards and their sanitary annexes.

4. **Cleanliness.**—The floors and walls of wards should be washable, and as non-absorbent as possible. Angles should be filled in, leaving a rounded-off surface. Mouldings and architraves should be avoided on doors and windows, doors should be flush panelled, and everything done to avoid harbouring dust.

5. **Comfort.**—A glazed window should be provided between every pair of beds. The windows should be low enough to enable patients to see out of them, but this may be difficult to arrange if splinter-proof protection is required. Prospect should be considered.

The walls, except those of ophthalmic wards, should be painted or distempered a light colour.

The blinds should be close-fitting, and the floors, partitions, etc., should be sound-proof.

Wards should not be in the vicinity of motor traffic.

Recreation and exercise grounds should be provided for patients.

6. **Lay-out.**—Hutted hospitals should always be constructed on the unit-ward system, *i.e.* with each ward holding as many patients as can conveniently be looked after by one nurse or hospital orderly.

Where time and materials permit, it is a great convenience to have covered corridors communicating with all wards, or at any rate covered communication between the operating block and the surgical case wards.

104. Wards and their accessories

1. **General wards.**—Pl. 56 shows a general ward containing 35 beds.* This is the most economical and convenient size, as it is the maximum number of beds which one nurse or orderly can efficiently look after. Wards should contain not less than 24 beds, or they will be wasteful of material as well as of personnel, as the accessories of a small ward must necessarily be nearly as large as those of a full-sized ward.

2. **Officer's ward.**—Pl. 57 shows a double ward suitable for 30 officers and containing special wards.

3. **Ophthalmic ward.**—The chief requirements are a subdued light, close-fitting green window blinds, and walls of a dark brown colour with a dull finish.

A dark room, 12 ft. by 10 ft., should be provided.

If a stove is installed it should be of the closed type.

4. **Mental ward.**—The doors should be provided with inspection plates and locks. The windows should have steel sashes and small panes, and be out of reach of the patients.

A padded room should be provided at one end of the ward. The floor should be covered with a mattress filled with cork chippings and enclosed in a waterproof cover, and it should be in panels to fit the room. The walls should be fitted with waterproof pads of coir fibre to a height of 7 ft.

5. **Accessories** (Pls. 56 and 57).—All wards should be provided with the following accessories :—

i. **Nurse's duty room.**—In a double ward the nurse's duty room should be centrally situated, and command the wards. In a single ward it should be situated at the end of the ward. It should be provided with a cupboard and a stove. An earth closet should be provided for the nurses close to their duty room.

Nurses' night duty rooms will also be necessary for a hospital which is on a partially hutted scale, *see* Appendix II, D. A small hut approximately 15 ft. by 10 ft. fitted with a stove, cupboard and shelving, and with an earth closet attached, is all that is necessary.

ii. **Scullery.**—This should be situated close to the nurses' duty room and is required for providing hot water, making poultices, washing utensils, warming food, etc. It should be provided with a small range with boiler, sink, coal store, general store and shelving.

iii. **Linen store.**—This may be conveniently connected with the nurse's duty room.

iv. **Sanitary annexe.**—This should contain the following :—

(*a*) Two water-closets, earth closets, or commodes for each large ward.

(*b*) Shelves for bed-pans.

It may contain in addition :—

(*c*) An ablution place.

(*d*) A bath-room.

It may sometimes be possible to arrange for one central sanitary annexe to serve two wards; this will save drainage.

6. **Standard ward hut.**—In order to cope with the large amount of constructional work which will become necessary in the event of general hospitals being brought on to the hutted scale a standard ward hut in steel framing and corrugated iron sheeting has been designed. This hut is illustrated on Pl. **56**, Fig. 1. The width is reduced to 18 ft. 6 in., in order to make use of the standard steel members adopted for stores sheds and other standardized buildings (Appendix IV).

Alternatively ward huts 20 ft. wide, as illustrated in Fig. 2, can be constructed in timber and corrugated iron sheeting, and mass production methods as described in Sec. **64** applied to their construction.

7. **Tropical design.**—In hot climates, the width of wards should be increased to 24 ft., and the height from floor to eaves to 10 ft.

8-ft. wide verandahs should be added as and when materials and labour permit.

Standard designs for a 24-ft. span hut in steel or timber and corrugated iron sheeting are illustrated on Pl. **25**, and should be made use of and adapted on the lines of the standard ward hut, where possible.

105. Constructional details of wards

1. **Walls.**—Matchboarding, or asbestos or other composition sheeting should be used for lining the walls. A dado should be painted on this lining to 5 ft. above the floor, and the remainder should be treated with a light coloured paint, or washable distemper.

All corners should be rounded, and unnecessary mouldings should be avoided.

2. **Roof.**—Corrugated iron coverings should have felt under them to assist in maintaining an even temperature in hot and cold weather, and also to lessen the noise caused by rain. Tarred felt on boarding makes a good roof covering, but increases the danger from fire.

3. **Floors.**—The floor levels leading out of and connecting wards together should be as unbroken as possible. Steps in covered ways, etc., are inconvenient to patients, stretcher bearers and hospital staff; and, where there are differences of level, inclined gangways should be provided instead of steps.

The floors should usually be made of 1-in. tongued and grooved boarding and covered with linoleum.

Superior floors may sometimes be made of 1¼-in. pitch-pine, teak, maple or other hardwood, and sized, stained, varnished and polished.

The floors of sanitary annexes and sculleries should be of Portland cement concrete.

4. **Ceilings.**—Matchboarding usually makes the best ceiling ; it should be nailed to the tie bars or collars.

Canvas nailed on battens may sometimes be used.

Mud or lime plaster on ½-in. galvanized wire netting may also be used, but the netting should be well secured to the ties or collars with battens bound with hoop iron, as it is liable to pull out staples or nails owing to the weight which it has to carry.

Ceilings should be limewashed, or painted, or distempered in a light colour.

5. **Doors.**—These should be double hung and 4 ft. wide, in order to permit of the easy passage of stretchers and beds.

Emergency doors should be provided ; they should open outwards or be hinged at the bottom and bolted at the top, so that when let down they form a ramp to enable beds to be wheeled out.

6. **Verandahs.**—Where these are provided they should be at least 8 ft. wide.

The floor should be flush with the ward floor.

They should be provided with chick matting or other form of anti-glare blind.

106. Operation block

(Pl. 58)

1. **The operating block** should be centrally and conveniently situated to the surgical wards, and access should be easy and comfortable for patients taken to it on wheeled vehicles.

Covered communication from it to the surgical wards is a great convenience.

2. **Operating theatre.**—The following points should be noted :—

i. The windows should be situated as near the eaves as possible and should be placed to give the best possible light. Direct sunlight is undesirable, and should be prevented by placing windows away from it, and by using obscured glass. Roof lights are unsatisfactory and always liable to give trouble, and should be unnecessary, especially in view of the increasing practice of operating by artificial (scyalitic) light.

ii. The walls and ceilings should be impervious, and washable with a hose. Stout asbestos sheets with the joints filled with putty are suitable as linings.

iii. The floors should be of Portland cement concrete with a surface of asphalt, terrazzo or some similar material, or covered with thick linoleum.
iv. The doors and windows should fit flush to avoid harbouring dust.
v. All fittings should be of glass or plated metal to facilitate cleanliness. No wooden fittings should be used.
    A sink should be provided.
vi. The whole interior should be painted with white enamel or washable paint.
vii. Some form of heating must be provided.
viii. Ventilators which would collect dust or be noisy should not be used.

107. Administrative and accessory buildings

1 **The administrative buildings** are most conveniently situated near the entrance to the hospital and close to the road. They comprise :—

Administrative block, Pl. **59,** Fig. 2.

Laboratory and general surgical dressing hut, Pl. **59,** Fig. 1.

Pack store, Pl. **60,** Fig. 1, which is essential for the safe custody of the kit of patients.

Quarter-masters' stores, Pl. **60,** Fig. 2, which should contain storage for linen, bedding, clothing and utensils.

Reception hut, Pl. **60,** Fig. 3.

2. **Accessories.**—Certain accessories, which are suitable for hospitals only, are shown on Pl. **61.**

Fig. 1 shows an enclosed cooking shelter for a hospital on a partially hutted scale, *see* Appendix II.

Fig. 2 shows an incinerator and bed-pan cleaning shed.

Fig. 3 shows a bath block.

3. **Dental blocks** will be provided as may be authorized, and will include operating rooms and workshops as required.

108. Mortuaries

Pl. **62,** Fig. 1, shows a mortuary suitable for a general hospital. It should be a self-contained hut, and separate from all other huts. It should contain a post-mortem room. There should be no means of viewing its interior from the outside. The drainage should not be connected to that of the remainder of the hospital.

Pl. **62,** Fig. 2, shows a mortuary suitable for an isolation hospital.

109. Accommodation for staff

1. The accommodation for the staff of a hospital will be similar to that provided for troops generally, and should be at a distance from the hospital buildings.

It will comprise :—

Officers' quarters and accessories.

Nursing sisters' quarters and accessories (Pl. **10**).

A self-contained camp for the R.A.M.C. personnel, with living huts, cookhouse, baths, ablutions, latrines, etc.

2. The nursing sisters' camp should be separated from the remainder of the accommodation for the staff, and, where possible, should have direct access to the hospital without passing through the other staff camps.

110. Isolation hospitals

1. Isolation hospitals are provided for infectious diseases, and are divided into groups of wards for each type of common infectious disease, as may be required.

The general principles of construction are the same as for general hospitals, but the wards are in much smaller units.

2. **Wards.**—A convenient unit is 14 beds, in two wards on either side of a central nurse's duty room, and with sanitary annexes at the ends.

Wards are usually grouped, 3 or 4 of them comprising a suitable group.

Pl. **63** shows a 14 bed double ward, and Pl. **64**, Fig. 3, shows a ward for 14 officers or nurses.

3. **Accessories.**—The following plates show certain accessories suitable for an isolation hospital.

Pl. **63**, Fig. 1. Administrative block.
Pl. **63**, Fig. 2. Pack store and quarter-master's store.
Pl. **64**, Fig. 1. Baths and ablution places.
Pl. **64**, Fig. 2. Disinfector block.

4. **Staff accommodation.**—It is usual to site an isolation hospital in the vicinity of a general hospital, so that the staff for the two hospitals can be accommodated together. In exceptional cases this may not be possible, in which case staff accommodation will be on similar lines to that for a general hospital, but naturally on a smaller scale.

CHAPTER XIX

REMOUNT DEPOTS AND VETERINARY HOSPITALS

111. Remount depots

1. The size and number of remount depots in a theatre of war will depend on the composition of the expeditionary force.

A remount depot will consist of a headquarters and one squadron, capable of dealing with 750 remounts, with an establishment of 9 officers, 370 O.Rs., and 30 horses for transport purposes.

If the remount establishment to be maintained in the theatre of war is in excess of these numbers it may be desirable to increase the size of the depot, if the site permits of it. Alternatively one or more additional depots may be formed as separate units.

2. **Site.**—The site should be dry and with good natural drainage. It should be close to water, and with good road access.

The total area required for a remount squadron is approximately 14 acres.

If there is more than one depot in the base area, they should be sited near each other for convenience of administration.

3. **Lay-out.**—A typical lay-out for one squadron is given on Pl. **2**, and a synopsis of the buildings required in Appendix II.

Each stable block is 262 ft. long by 28 ft. wide, with a forage store and harness room 28 ft. by 12 ft. at one end, and is divided into two, longitudinally, by a central partition. Each side is divided into 10-ft. bays by swinging bails, each bay accommodating 2 heavy or 3 light horses, *i.e.* an average of 126 horses for each stable.

Details of stable and other accessory buildings required are given on Pls. **65–67**.

Stable blocks should be at least 20 ft. apart. In the tropics this distance may be doubled, the heights of the stable may be increased to a minimum of 12 ft. at the eaves, and false roofs of native matting, rushes, etc., may also be required.

In order to get advantage of any cool wind at night it may also be necessary to site stable blocks in echelon.

4. The traffic round stables is heavy, and the spaces between stables and round the troughs should be macadamized (3-in.) on a good layer of soling, and rolled.

At least two roads giving access to the depot are necessary, and all made roads in the depot should be of the same solid construction as the spaces round the stables.

5. Once a depot is placed on the hutted camp scale of accommodation, an exercising track and crush is more economical than the kraal system (Pl. 68).

6. **Water supply.**—It may often be possible to utilize a a source of water for animals which is unfit for human consumption, and thus economize in the piped supply of drinking water. A consumption of not less than 10 gals. a day for each horse must be allowed for (15 gals. in the tropics), and elevated storage tanks of not less than half the day's consumption should be constructed with gravity supply to the troughs.

Adequate surface drainage must also be provided round the latter.

7. **Disposal of manure.**—This may present considerable difficulties, and, if disposal locally to farmers, etc., cannot be arranged, it may be necessary to lay a line of decauville, and remove the manure to a suitable locality for dumping.

112. Veterinary hospitals and convalescent horse depots

1. A lay-out is given on Pl. 3, and a synopsis of the accommodation required in Appendix II for a veterinary hospital for 1,000 sick horses.

The number of hospitals required will depend on the strength and composition of the expeditionary force, but all hospitals in any one area should be grouped together.

2. **Site and lay-out.**—The requirements for siting and lay-out are very similar to those of a remount depot, but proximity to a railway station is very desirable, in order to minimize the distance horses may have to be conveyed by road.

Stables should be arranged in units of five, each stable holding 50 horses, with one isolation unit accommodating 250 horses separated from the remainder.

The spacing between stables should be not less than 20 ft., except in the isolation unit, where it should be a minimum of 50 ft.

A small forage mixing store and harness and utensil store should be provided at the ends of each stable.

The spaces between stables and round troughs should be macadamized as for remount depots.

A horse dip and accessory buildings should be provided in each hospital, and also an exercising track and crush (Pl. 69).

3. If hospitals are grouped one hospital should be provided with a Turkish bath for the treatment of all mange cases.

4. Corn crushers and chaff cutters will be required in each hospital. They should be driven by mechanical means; either a 10 to 12 H.P. engine or electric motor.

With a group of hospitals, corn crushing and chaff cutting should be concentrated in one building to serve the group of hospitals.

5. Water consumption would be about 15,000 gals. a day for a 1,000-horse veterinary hospital, and the considerations as regards water supply and drainage are similar to those for a remount depot.

The disposal of horse manure also presents the same difficulties.

6.—i. **Horse carcase economizing plant.**—Considerable difficulty will always be experienced in the disposal of carcases of horses, and special plant for dealing with them will probably be found necessary in a campagin of any duration.

ii. A horse carcase plant to deal with 10 horse carcases a day will probably be sufficient at the start, but may have to be expanded later.

iii. The buildings required for a 30-carcase plant consist of one shed, 40 ft. by 30 ft., to contain slaughtering and cutting up sections, and space for machinery and reducing plant; and one shed, 64 ft. by 10 ft., divided into two skin-curing rooms, skin store and office.

With the 10-carcase plant, the skin store can be omitted, the general store and office combined, and the other rooms reduced *pro rata*.

iv. The sheds may be of wood and galvanized iron, on 9-in. dwarf walls, with concrete floors. The floor of the economizer should be graded with a slope rising to 2 ft. 3 in. above the outside ground level at slaughtering sections, to aid in the delivery of carcases, and 6-in. cross channels are required at intervals for cleaning purposes.

v. The centre of the floor of the skin-curing rooms should be slightly raised with a 6-in. channel forming a kerb all round as shown on Pl. **70**.

vi. The lay-out and construction of these plants are shown on Pl. **70**.

7. **Convalescent horse depots.**—The requirements as regards site, lay-out and stable accommodation are very similar to those of veterinary hospitals, and require no further elaboration.

CHAPTER XX

MISCELLANEOUS CAMPS, OFFICES, ETC.

113. Headquarter camps

1. The provision of accommodation should not be necessary for the headquarters of formations, except possibly of G.H.Q. Headquarters are mobile, and will normally be billeted in populated countries, or provided with the necessary tentage in the case of operations in undeveloped countries.

2. Should position warfare intervene, however, or during prolonged halts for other reasons, the provision of accommodation may be necessary, either to supplement what is available in billets or to provide complete accommodation.

The following paragraphs indicate what is necessary in the latter case.

3. The scale on which any particular headquarter camp will be constructed will depend on conditions so variable that no fixed scale can be laid down.

4. The following points should be borne in mind when a headquarter camp is being planned :—

i. Aspect and prospect should be given full consideration.

ii. Good motor road access is essential.

iii. There are usually a number of horses in a headquarter formation, and where possible stables should be sited well clear and to leeward of living huts.

iv. In certain headquarter camps there may be a considerable amount of interrogation of prisoners of war by the general staff, and office, prisoner and guard accommodation should be provided apart from the other offices.

v. The offices of the staff of the formation should be grouped together, either in the same building or in adjoining ones;

The commander's office will usually adjoin those of the general staff. The office of the artillery headquarters should, wherever possible, be close to those of the general staff; the offices of other subordinate headquarters, and those of representatives of the various services, may be in separate buildings, and, if space is limited, may without serious inconvenience be located at some distance.

vi. The commander of the formation will usually require a separate office, which should be large enough for conferences with his immediate subordinates.

vii. Commanders, and staff officers of the rank of Major General and upwards will normally require a sitting room as well as a bedroom, bathroom and latrine. Bed and sitting rooms should not exceed 180 ft. super each.

viii. Messes will normally be provided on the following scale :—

Brigade headquarters.—1 mess.
Divisional headquarters.—3 messes (for commander, staff and services respectively).
Corps headquarters—3 or 4 messes, as required.

Messes for headquarters of other formations will be on similar lines.

ix. As headquarters of fighting formations are likely to move after the end of any period of position warfare, it is desirable that they should be housed as far as possible in sectional huts, which can be dismantled and re-erected rapidly.

x. Electric light will always be required by divisional and corps headquarters, even in the tented stage of accommodation. The field park company, R.E., carries a field lighting set for lighting divisional headquarters, and a lorry lighting field set is provided on the establishment of a corps headquarters for lighting the latter.

Diagrammatic lay-outs for hutted camps for a corps and divisional headquarters are given on Pls. **6** and **7**, and these can be taken as a basis for modification for camps of other formation headquarters.

114. Offices

1. In the field, offices may vary from the small company or regimental office and store illustrated on Pls. **15** and **16** to the large blocks of offices required at the base or other subareas of the line of communication, for depots and administration services in general.

2. As a rule offices will be amongst the first accommodation to be provided in huts, owing to the great inconvenience and loss of efficiency resulting from working under canvas.

3. Offices can be divided into two main groups :—

i. Unit and regimental offices.
ii. Departmental and administrative offices.

4. Unit and regimental offices will normally be accommodated in huts of 16-ft. or 20-ft. span, communication between offices being by a covered verandah 4 ft. to 6 ft. wide along the front, and by connecting doors between adjacent offices.

5.—i. Departmental and administrative offices, particularly when there are large numbers of clerks employed, will normally be accommodated in huts of 28-ft. span with a central 4-ft. passage running from end to end; and without verandahs.

ii. The distances between adjacent blocks of offices should be not less than 10 ft. longitudinally and 20 ft. laterally.

iii. Blocks should not be unduly long, but their lengths will be governed largely by the numbers required to be housed under one roof for the convenience of the administration concerned.

6. **Construction** :—

i. The normal height to the eaves should not exceed 8 ft. in temperate zones, and 12 ft. in the tropics.

ii. The floors should be of wood, or solid with a concrete or stone-flagged surface.

iii. The normal construction will be of wood and corrugated iron, and, where severe winters are to be expected, huts should be lined and ceiled, and provided with stoves.

In any case offices for senior officers should be lined and ceiled as soon as possible.

With a collar-beam truss, the ceiling can be fixed to the collar; otherwise huts should be ceiled under the rafters or purlins, to give the maximum cubic content for the rooms.

iv. Ample window light should be provided, and electric lights over every pair of tables.

Various arrangements are given on Pl. **15**.

v. In the tropics, verandahs should be provided on the south sides of huts, with clerestory ventilation above, and ceilings and wall linings should be of a material which has the greatest possible heat-resisting properties.

7. **Scales of accommodation.**—The following scale of provision should not be exceeded :—

i. Commanders and senior staff officers of formations, directors of services or their representatives	300 f.s.
Conference rooms	As required.

Unit commanders, etc. (with adjutant)	..	300 f.s.
Company commanders and officers generally		150 ,,
If two or more in the same office ..	each	100 ,,
Clerks-unit space	..	50 ,,
If two clerks in one office	..	150 ,,
If three clerks in one office	..	200 ,,

If four or more .. 200 plus 40 f.s. for each clerk over 4.

These floor areas give the necessary allowances for stationery and filing cupboards, gangways, etc.

ii. In the tropics 50 per cent. should be added to these areas except for commanders, etc., for whom the area should remain at 300 f.s.

115. Prisoners of war camps

1. The most convenient unit size for a prisoners of war camp is one for 500 men, and the lay-out for a camp of this size is given on Pl. 8.

2.—i. The boundaries in these camps should be straight, to allow them to be commanded throughout their length by a sentry.

ii. The inner enclosure fence should be constructed of posts 8 ft. 6 in. high, and from 4 to 6 in. in diameter, and spaced 8 ft. to 9 ft. apart; each post should be wound spirally with barbed wire from top to bottom. Horizontal barbed wires should be fixed to these posts externally at 6-in. intervals, and these horizontal wires should be laced in each bay with two equidistant vertical wires.

iii. Pointed pickets about 3 ft. long, and 3 in. in diameter should be driven into the ground opposite to and 3 ft. on the outside of each post.

iv. Inclined wires should be led from the top of each post to the adjacent picket, and horizontal wires should be stretched along these inclined wires at 1-ft. intervals to form an apron. The space between the fence and the apron should be filled with loosely coiled barbed wire.

v. An overhanging curtain of barbed wire about 1 ft. 6 in. in length should be fixed on the inside of the fence.

vi. A knife rest should be provided, which may be drawn across the entrance gateway each evening, so as to make a continuous fence. Gates should open outwards to enable this to be done.

vii. At each of the four corners of the inner enclosure, two screens, 10 ft. wide and 8 ft. high, and forming a right angle, should be constructed of wood or corrugated iron and painted white.

Motor headlights can then be placed so that their light shines directly on these angles, to assist sentries in the rapid detection of any attempt to escape.

viii. Raised sentry posts should be provided at the corners, if required.

3. The outer enclosure fence and parade ground fence should be constructed of 8 ft. high posts, at intervals of 8 ft. to 9 ft., and with 12 equidistant horizontal strands of barbed wire.

4. **Scales of accommodation.**—As far as possible prisoners of war camps will be established on the partially hutted scale from the start; a schedule of the accommodation which should be provided is given in Appendix II (H). Where climatic conditions are severe programmes for the complete hutting of camps will be on the same lines as, and follow on, those for the troops.

116. Military prisons

1. Military prisons will be established at convenient points in the line of communication area. They will be normally in units each accommodating 300, and a lay-out for a prison for this number is given on Pl. **9**.

2.—i. The compound should be enclosed by a double fence, and includes a living compound and a cells compound.

ii. The living compound should be wired off into sections to contain 100 men each.

iii. The cells compound should contain cells (Pl. **71**) on a scale of 44 for 300 men. Cells should be sited in two straight blocks, with an enclosed compound 15 ft. wide between them, and with a covered corridor outside each block. A room for N.C.Os. should be provided at the entrance end of each block.

3. **Construction.**—The walls of the cells should consist of stout wood framing, lined inside with stout sheet iron, and covered outside with wood, or wood and rubberoid or other suitable covering.

The walls between the cells should be double and packed with a suitable material to deaden sound.

The ceilings of the cells should be lined inside with stout sheet iron.

A small hopper window, opening inwards and fixed close up to the ceiling, should be provided in each cell. Stout iron bars, 3 in. apart, should be firmly fixed outside.

The doors of the cells should be made to slide with runners, and should be provided with strong iron bar fastenings.

Stoves should be provided in N.C.Os.' rooms only.

4. **Fences** :—

i. The outside fence should consist of posts and rails with 8-ft. sheets of corrugated iron fixed on the inside. The inside fence should be 5 ft. from the outer one, and should consist of posts 7 ft. high with close horizontal barbed wire strands.

ii. An overhanging curtain of barbed wire of about 1 ft. 6 in. should be fixed on the inside. Loose coils of barbed wire should be laid inside the inner fence to a width of 5 ft.

iii. One entrance gateway only should be provided in the compound fence.

iv. The ends of the cells compound should be provided with a corrugated iron fence 8 ft. high, and all framing, nuts and washers should be on the outside.

A strong barbed wire fence should be erected all round the cells compound.

5. **Accessories.**—The following accessory buildings should be provided :—

i. In each compound :—

Ablution places.
Combined baths and disinfector.
Combined cooking shelter, store and drying room.
Latrines.

ii. In the main compound :—

Ablution places.
Incinerator shed.
Latrines.
Quarter-master's stores, medical officer's room and guard room (in one block).

iii. Outside the main compound, for the staff :—

Ablution places.
Governor's quarters, ablution room and kitchen, and offices (in one block).
Latrines.
Mess and kitchen.

CHAPTER XXI

DEPOTS—GENERAL CONSIDERATIONS

117. General

1. Extensive engineer work will be required in connection with the establishment of the following base depots :—

i. R.A.S.C. depots (Secs. **118–129**).
ii. R.A.O.C. depots (Secs. **130–132**).
iii. Engineer store depots (Sec. **133**).
iv. Transportation depots (Sec. **134**).

2. The primary consideration is the railway lay-out. This is dealt with in Military Engineering, Vol. VIII, which includes standard types of lay-outs for supply and ordnance depots. All other considerations will be subordinated to the necessity for the most suitable railway lay-out practicable in the particular circumstances.

3. The accommodation required will differ with every theatre of war and it is not advisable, therefore, to lay down any standard scale of provision.

4. The engineer work demanded by the service concerned will normally comprise the following :—

i. Construction of offices.
ii. Shed construction and flooring.
iii. Accommodation for personnel.
iv. Lighting.
v. Drainage.
vi. Water supply.
vii. Fire protection.
viii. Protection against air attack.
ix. Supply of power.
x. Provision of store handling appliances.
xi. Provision of dunnage.
xii. Fencing and direction boards.
xiii. Roads.

5.—i. The **construction of offices** constitutes the first demand ; for office work essential to efficient general administration cannot be conducted efficiently under canvas. Adaptation of any available existing accommodation will clearly be the quickest method of provision, and should b

adopted, at any rate as an interim measure, pending hut construction better adapted to the organization of the service concerned. Such adaptations will include provision of light, telephones, latrines, etc.

ii. (*a*) **Shed construction and flooring.**—Whilst many stores can well be stacked in the open, others will require light shedding; and in the case of stores which must be issued in detail, a process involving "breaking bulk," closed sheds will be required, as for example groceries and certain categories of ordnance stores.

(*b*) The time and the vast quantities of material required will make it unlikely that shedding will be provided for all categories of stores in every depot. In fact, in any but the most prolonged operations it is unlikely that the following provision will be exceeded:—

Depot.	Percentage of total areas for shedded stores.
Supply (including petrol)	20
N.A.A.F.I.	20
Ordnance (excluding vehicles) ...	70
Ammunition	10
Engineer stores	10
Transportation	8

(*c*) It is essential to look ahead, and to plan for ultimate requirements; and bearing in mind the great extent of the engineer work required, the provision of standard shedding suitable for all types of depot, except perhaps purely temporary ones (Sec. **181**), is indispensable if the work is to be carried out in any reasonable time.

In consequence, spans for stores shedding have been standardized at 36 ft., and a steel shed of this span is illustrated on Pl. **23**, which may be manufactured in bulk either at home or in the overseas base workshops.

Working drawings, specifications and bills of quantities for this shed are also sealed.

An alternative design in timber for the same span is given on Pl. **24**.

(*d*) Store sheds may be of any length as required, up to a maximum of about 400 ft.; and, if wider than 36 ft., can be built up of two or three 36-ft. spans. The maximum width will seldom exceed 108 ft. A shed of this width is illustrated on Pl. **72**. If considerable enemy bombing is to be anticipated store sheds may have to be reduced in size and a considerable distance apart.

Where conditions are exceptionally favourable, double width sheds (216 ft. wide) may be possible, and are often more convenient administratively.

The excessive amount of spoil to be moved to get level floors on sloping sites, and the difficulties of disposal of storm water on flat sites will usually rule them out.

(*e*) In depots requiring these large sheds railway sidings are provided along either side of each shed, and the standard 108 ft. wide shed is also given a covered platform area 19 ft. wide on each side.

This area, which should be as free from pillars or other obstructions as possible, provides sufficient space for loading and unloading, sorting, and power and hand trucking.

It should be borne in mind that goods allowed to stand for any length of time on a platform are a hindrance to efficient working, and ample means for their removal must be provided.

Although platforms at truck floor level are a very great convenience, it is essential that they should be on the same level as the shed floors, and the vast amount of filling required to raise the floor of a large shed will make it almost always impracticable.

In exceptional cases it may be possible to have sidings running in cuttings of the requisite depth, viz. 2 ft. 9 in., but this will only be possible where the configuration of the ground permits.

Platform roofs must conform to the railway structure gauge of the particular theatre of war.

Doors of the sliding or, preferably, roller type should be provided at approximately 50-ft. intervals along the sides, and at the ends, as required.

Ample daylight is essential, and this is best provided by roof lighting. Standard roof lights fitted into a sheet of corrugated iron are illustrated on Pl. **105**.

iii. **Accommodation for personnel.**—Camps for operative personnel and labour are required.

iv. **Lighting.**—Artificial lighting is essential for offices from the start; it will also be required in sheds. Arrangements should be made that all lights visible from the air can be turned out from some central place in the event of air attack, and a subsidiary system of pilot lights not visible from the air should be provided. External lighting is indispensable in the railway lay-out, for the sorting and despatch of trucks will normally be carried out by night.

Scales of lighting are given in Appendix III.

v. The **drainage** of depots is a matter of primary importance. In order to economize in railway construction, every possible advantage will be taken of low-lying flat country; in consequence the general drainage problem must be studied. Such areas are usually drained by intersecting dikes with an

almost imperceptible fall. The construction of rail sidings is apt to block such dikes; it is usually essential for barrel or other type culverts to be constructed wherever a line crosses a drainage ditch, otherwise the railway embankments will form a pound in which the water will collect.

To prevent a loamy soil being pounded into a quagmire, a thin layer ($\frac{1}{2}$ in. to 1 in.) of sand may be spread; this will be trodden into the surface by the labour of the depot, and will form a reasonably impermeable surface, off which rainfall will run freely to the drainage ditches.

vi. **Water supply.**—(*a*) Apart from the water supply of the camps a few drinking water points are desirable in extensive depots.

(*b*) Water points for locomotives will also be required; these may conveniently be supplied from the system providing fire protection (*see* vii., below).

vii. **Fire protection.**—This is afforded primarily by judicious stacking, that is by alternating stacks of inflammables and of non-inflammables, and by leaving "fire-breaks."

Fire engines are of somewhat doubtful value in depots; usually they cannot be got rapidly to the site of a fire on their own wheels; and, whilst transit on a rail track is admirable in theory, it is only rarely that at the time of an outbreak of fire the lines are sufficiently clear of traffic to permit free movement. Consequently it is desirable to provide a ring main of 4 in. or larger diameter, with a pump installation, preferably driven by an electric motor (with a petrol engine standing by) to force water through the main under the necessary pressure (100-ft. head); and provided with the necessary stand-pipes to which fire hoses may be attached (*see* Military Engineering, Vol. VI).

In any case movable fire screens should be provided. These consist of plain or corrugated iron sheets mounted on a framework of iron, and capable of standing without support. Screens should be not less than 9 ft. in height, and should be easily moved by hand. Sufficient screens should be provided to surround any one stack.

Until these can be supplied, loose sheets of corrugated iron, which can be laid against a burning stack, will be found useful.

viii. **Protection against air attack.**—Where considerable hostile air action is to be expected special steps must be taken to provide protection against it. This will consist normally of traversed shelter trenches at various points in the depot for the protection of the personnel, with perhaps, in extreme cases, dug-outs for the staff; and of traverses round the store sheds or stacks. These will usually be confined to sheds or stacks

of inflammable stores only; but this may be extended, as labour and time permits, to all the sheds in a depot.

ix. In addition to the heavy demand for electric current for lighting purposes, there will be a heavy demand for current for power purposes. The supply of electric current is considered in Chapter XXXI.

x. The methods of stacking in a depot (para. vii., above) and the breaking of bulk (para. ii., above) will often involve considerable carry from the stacks or bins to railway trucks, and the provision of various store handling appliances will become necessary. These may consist of tramway, power or hand trucks, light runabout cranes, conveyors, pilers, etc., as required in any particular case. Plank or concrete runways will also be required in connection with some of these.

xi. **Dunnage.**—While dunnage is normally a R.A.O.C. service, the R.E. will generally be required to make the initial supply on their behalf. This supply will always be a difficulty. Timber is normally required in vast quantities for field engineering and railway construction, in addition to the requirements for works services. The outer slabs from forestry operations will not usually suffice for the dunnage required, even if transportation is available. Every possible material must, therefore, be pressed into this service, *e.g.* sand, slag, cinders, broken packing cases, derelict stores, brickbats, brushwood. Concrete is, of course, desirable, but again the interests of many important services may forbid its use. On loamy soils half an inch of sand spread over the surface of a depot and trodden in will form a fairly waterproof surface off which rain will flow. An efficient system of drainage will in many sites considerably reduce the demand for dunnage. Dunnage will often have to be provided as quickly as possible, and before the engineer work has been completed. Usually the service concerned will be able to improvise methods to keep perishable goods off the ground.

xii. **Fencing.**—This will be demanded; some may be essential, especially in Oriental countries. But in general it affords small protection, and it will usually not "pay for itself."

Notice boards, preferably of metal, will be necessary.

xiii. **Roads.**—Unless road transport forms the line of supply of the army, roads should be cut down to a minimum in depots, nor are road accesses necessary for base depots except to the offices and in the case of gun and vehicle parks.

Where road access is necessary, endeavour should be made to avoid level crossings. Sufficient space must also be provided between sidings, stacks and buildings for vehicles to manœuvre, turn round and pass each other.

Lack of road space is frequently the chief difficulty when the maximum output is required in an emergency.

Local parks and detail issue stores require road access. Whether they are fed from the depot by road or by rail depends on the circumstances. The most economical method will be adopted. Similarly, if some road transport is employed to forward areas, it may be economical to use sidings with road access in a manner similar to railheads (Military Engineering, Vol. VIII, 1929, Pl. 10) rather than to run roads into the depot.

6. Whatever may be the size of the original expeditionary force, and the depot accommodation required for that force, the lay-out must always provide for expansion (*see* Sec. **16**).

CHAPTER XXII

R.A.S.C. DEPOTS (EXCLUDING PETROL AND COLD STORAGE)

118. Types of depot

R.A.S.C. depots in a theatre of war may comprise some or all of the following :—

i. Supply depots—main, intermediate, advanced and field.
ii. Vehicle reception depots—main and advanced.
iii. Base M.T. stores depot.
iv. Petrol depot.
v. Cold storage installation.
vi. Heavy repair workshops.

119. Supply depots

1. **The size and lay-out** of a supply depot is governed by the following factors :—

i. The tonnage to be handled by the depot.
ii. The number of days' reserve to be held.
iii. The possibility of expansion.
iv. The degree of dispersion necessary owing to the possibility of air attack.
v. Variations in rations due to the climate and the composition of the force.

2.—i. Supplies are classified in seven groups as under :—

(*a*) Cased goods and sacked goods other than forage.
(*b*) Forage.
(*c*) Frozen meat.
(*d*) Fuel, lighting materials, disinfectants and other chemicals.
(*e*) Unpacked commodities (including local produce).
(*f*) Petrol and lubricants.
(*g*) Salvage.

ii. At the base petrol would be contained in a sub-depot (with installations for the repair and manufacture of cans and cases (Chapter XXIII)) conveniently near the main depot, and frozen meat would be handled in a cold storage sub-depot at the water side (Chapter XXIV).

In the main supply depot itself, therefore, the groups would be reduced to five. Normally a main supply depot would be planned to hold 60 days' stock.

iii. Intermediate and advanced depots would be organized in the seven classified groups, as petrol and frozen meat would

be handled in these depots, and would normally be planned to hold 30 days' stock.

3. **Main supply depot.**—The railway lay-out for a supply depot for 150,000 men and 45,000 animals is given in Military Engineering, Vol. VIII (1929), Pl. **5.**

This lay-out gives sufficient space for 60 days' stock.

The total depot area is 88 acres, with a storage area of 17·6 acres, of which 8 acres is covered accommodation comprising 8 sheds, each 395 ft. by 108 ft.

This gives a dispersion factor of 5 $\left(\frac{88}{17 \cdot 6}\right)$.

If the depot is liable to gas attack, the covered storage accommodation may have to be increased to 90 per cent. of the total storage area.

In addition to the storage sheds the following accommodation will be required :—

i. Office accommodation.

   (*a*) Main offices for 10 officers and 20 clerks ... ... 2,500 f.s.

   These should be in a central position.

   (*b*) Group offices, one for each group, each 450 „

   These can be either inside, or semi-detached at either end of the stores buildings.

ii. Latrines and ablution places.

iii. Guard room and fire engine shed.

4. **Lay-out** :—

i. The lay-out is governed entirely by the necessity of obtaining a suitable railway lay-out (Sec. **117,** 2).

   Store sheds are placed in alternative " grids " to give greater dispersion against air attack. All grids are of the same size and contain 1,000 ft. of straight siding to accommodate an average 40 10-ton wagon train (*see* Military Engineering, Vol. VIII, 1929, Sec. **32**).

ii. The salvage sheds should be the end ones fed by rail transport. This will be necessarily a roomy section, as it deals with all empties, dunnage and the reconditioning of cases and sacks.

iii. A road transit shed will also be required in the larger depots. This should be erected clear of broad gauge rail tracks preferably at one end of the depot, and road access to it should not, if possible, cross any of the rail tracks. Traffic between it and the main sheds should be by tramway, track or six-wheeled vehicle, etc., as convenient. Its floor should be on a level with that of the average road

vehicle, or, if this cannot be managed, loading platforms must be provided.

The shed should be of similar dimensions to the main sheds.

iv. The main offices and fire engine shed should be sited in a central position.

If not concentrated in one building the main office buildings should be sited as close to each other as possible. Section officers should be in or adjacent to their respective store sheds.

The guard-room should be at the main entrance.

v. Latrines and ablution places should be adjacent to the main offices, and additional latrines should be provided in places convenient to the stores areas.

5. **Construction** :—

i. The normal type of shedding provided will be standard store shedding 108 ft. wide made up in 15-ft bays, as illustrated on Pl. **72**.

ii. Where standard shedding is not available local designs must be adopted to suit the materials available. In any case sheds should be not less than 14 ft. high and clear spans 36 ft. A suitable design in timber is illustrated on Pl. **24**.

iii. **Floors.**—Sec. **117**, 5, v, indicates the nature of the flooring required for supplies. Except where they are of concrete some protection from rodents is desirable: for this small mesh galvanized iron wire, laid about 12 in. below the floor surface, is suitable.

iv. Sheds should be well lit and ventilated, as climate-proof as possible, reasonably secure against theft, and provided with electric light, if possible.

v. It is desirable to stack coal and coke against walls where possible, to enable stock to be taken easily. The wall should be marked off by perpendicular lines into 10-ft. bays, with a horizontal line 10 ft. from the ground, to enable the cubic contents to be measured.

Should hay baling or oats winnowing be undertaken separate sheds will be required for these services.

6. **Order of work** :—

i. Sheds for cased and unpacked goods should be built first; hay, oils and other commodities can very well be stacked in the open until it is possible to build the large sheds required for them.

ii. Construction of cover for hay, coal and coke, and salvage should be left to the last. Because of its bulk, it is in fact preferable to stack forage in the open, unless roomy sheds are available.

Shed accommodation for all supplies is, however, desirable when possible, as sail-covers and tarpaulins do not give complete protection against the weather, and do not afford cover for the supply personnel or protection against pilfering or sabotage.

iii. Except in a campaign of considerable duration it is unlikely that the general proportion of covered storage given in Sec. **117**, 5, ii (*b*), will be exceeded.

7. **Internal depot traffic** :—

i. This should be by mechanical means, wherever possible, *e.g.* electrically operated conveyors and pilers, gravity plant, motor or electrical trucks; or failing these by tramway.

The provision of conveyors and gravity plant should be the first consideration, as they are more elastic than a tramway system.

Suitable equipment, at any rate, for the start would consist of :—

Conveyors.—28 7·5 h.p. 5-ft. motor units with 1,680-ft. run of conveyor in 10-ft lengths.

Pilers (in sheds).—16 5 h.p. 18-ft. pilers giving a lift of 12 ft.

Pilers (for forage in the open).—12 7·5 h.p. 24-ft. pilers giving a lift of 18 ft.

A certain number of hand trucks and gravity rollers will be required for use when the employment of conveyors is not practicable, and for connection to the conveyors with gravity roller bends to permit of packages being run at right angles to the conveyor line.

Power points for plugging in the motors should be fixed on either side of the doors of the sheds.

ii. If oats arrive in bulk by water, suction and automatic weighing plant at the quayside will save considerable time and labour.

iii. Yard cranes should not normally be necessary in a supply depot, but the possibility of their need should not be overlooked.

Should they be required a lifting capacity of 30-cwt. will be ample for all purposes in the case of track cranes; but runabout cranes of 10-cwt. capacity will usually be found of more general utility.

8. Goods may be received and despatched via water, rail or road.

Local produce, for instance, will mostly come in by road, or water if the depot is sited on a river or canal; and the construction of sheds and provision of facilities must be such as to cope suitably with the form of transport in use.

9. Weighbridges may be necessary in large depots, both for rail trucks and road vehicles. For road transport they should be large enough to take a loaded 5-ton lorry.

In the smaller depots the normal type of scales provided by the R.A.O.C. may suffice for all weighing.

10. **Dunnage.**—Dunnage is necessary for all supplies. Almost any sort is suitable. In the case of hay, however, the tops or first cuts off tree trunks, laid in two layers, and held together with 8-in. wire nails, are the best. Failing this, wooden slats or empty preserved meat or other cases, when available, answer the purpose.

11. **Fencing.**—Fencing the boundaries of the depot is desirable, but not essential, unless the depot is situated in the vicinity of a populous area, or in Eastern countries, where extensive pilfering might otherwise be expected.

12. There should be separate entrances and exits for traffic.

13. Notice boards should be provided freely, to indicate traffic directions, offices, store groups, fire hydrants, etc.

14. **Fire precautions.**—Many supplies are inflammable, some of them highly so. 4-in. or 6-in. fire mains with hydrants at frequent intervals should be provided in the depot.

Stacks of hay should be limited in size, and should be separated by wide fire breaks. If possible, the stacks should be sited so that the prevailing wind (if any) will not blow burning wisps of hay from one stack to another.

15. **Accommodation for personnel.**—Accommodation will be required for 16 officers and about 100 men.

Additional labour will also be required on the basis of 3 men per 2,000 men feeding strength of the depot.

Camps should be outside but convenient of access to the depot.

16. **Constructional material.**—An approximate list of the major items of engineer material for the construction of the depot is given in Appendix IX.

120. M.T. vehicle reception depots

1. Although the functions of an M.T. vehicle reception depot are dependent on the system adopted for equipping units with M.T. vehicles, *i.e.* whether after arrival overseas

or at home, it is probable that in most theatres of war the depot will have to function not only as a reception vehicle depot, but as a reserve equipping and distributing centre as well.

2. Vehicles arriving at the overseas base may arrive with their superstructures dismantled, equipment removed and packed in boxes, etc.

The vehicles on arrival will then have to be removed to the reception depot, under their own power if possible, or by towing or rail transport.

In order to clear the dock area quickly, particularly of vehicles on wheels, but which must be towed, the depot should be within reasonable distance of the docks, and must have both rail and good road access.

3. The functions of the depot are inspection, equipping, conditioning and issue.

Conditioning may involve minor repairs such as fitting superstructures, altering lamp brackets, charging accumulators, attention to tyres, for which power pumps will be required, and remedying minor defects, but generally speaking any repair likely to take more than 48 hours would be relegated to the heavy repair shop, M.T.

4. **Selection of site.**—The chief points to be aimed at in a suitable site are :—

i. Good road and rail access.
ii. Level ground on which good standings can be made easily.
iii. Ample space for expansion.
iv. Proximity to the dock area, but not to civilian dwellings or native bazaars.

Even though existing buildings may be available it will usually be found that they do not lend themselves to a systematic lay-out (para. 5, below), and that they are liable to cramp the site.

It is generally advisable, therefore, to select an open space of the size required, but one with good communications, or one where they can readily be provided.

5. **Lay-out.**—This should be arranged on two basic principles :—

i. That the flow of vehicles should be from one end to the other.
ii. That there should be as little movement as possible of vehicles within the depot.

A typical lay-out, embodying these principles is illustrated on Pl. **73**.

On arrival, vehicles pass into the inspection department, where they are classified as fit, minor repairs, or shop repairs.

Vehicles in the first two categories are passed straight to their respective fit parks, those in the third to the unfit parks.

Equipping, minor repairs, etc., will be carried out in the fit parks, where the vehicles remain until finally issued.

Unfit vehicles are either taken into the shops, or evacuated to the heavy repair shops.

Each park is divided into sections for the different classifications of vehicles, *e.g.* motor cycles; cars, vans and ambulances; light lorries; heavy lorries; and special vehicles.

Offices, equipment stores and workshops should be centrally situated, and an adequate supply of latrines and ablution places provided.

6. **Buildings.**—The following buildings will be required:—

i. Office block, approx. 1,800 f.s. I.M.T. hut 400 f.s.
ii. Equipment store, approx. 17,280 f.s., fitted with racks.
iii. Workshops, approx. 17,280 f.s.
iv. Cover for cars, approx. 17,280 f.s.
v. Cover for motor cycles, approx. 4,500 f.s.
vi. Petrol and oil store, 5,400 f.s.
vii. Paint store, 1,080 f.s.
viii. Fire station, 720 f.s.
ix. Latrines and ablution places, 2 sets.
x. Police hut, 720 f.s.
xi. Decontamination hut, air raid shelters, etc., as required.

Standard span shedding will be utilized as far as possible for all these.

7. Accommodation will be required for approximately 300 officers and men.

8. **Roads and standings.**—Good road access should be provided to every section park, and hard standings in the parks themselves.

For the lay-out on Pl. **73** approximately 1,500 yards run of 20-ft. road will be required, and a total standing area of 193,000 ft. super in the various parks.

9. **Lighting.**—Good lighting, if possible electric, is indispensable, and should be installed in all buildings and parks.

10. **Fencing.**—The whole depot and each individual park will have to be fenced round with an unclimbable fence.

11. **Water supply.**—An ample supply of water is required, with standpipes in every park for filling radiators, and adequate fire mains must also be provided.

12. **Construction materials.**—An approximate list of the major items of engineer material required for the construction of the depot is given in Appendix IX.

121. Mechanical transport stores depots

1. **Site.**—The depot can be sited on any suitable ground in the base area for which good road and rail access can be arranged; but, where there is no broad gauge system, it should be adjacent to the dock area.

It will seldom be possible to find existing buildings suitable for conversion into a M.T. stores depot, and any attempt to adapt them by constructional and other alterations will almost invariably lead to congestion and difficulties in the handling of stores, and render future expansion a matter of great difficulty, if not an impossibility.

It is usually best, therefore, to select an empty plot of ground and to build thereon shedding of a suitable type and equipped to facilitate the systematic and rapid handling of stores.

The total area required is about 21½ acres (936,540 f.s.).

2. **Lay-out.**—The lay-out should provide for storage in accordance with the following table :—

TABLE B.—STORAGE ACCOMMODATION REQUIRED IN BASE M.T. STORES DEPOTS

Description of building. (1)	No. (2)	Size. (3)	Total floor space for each group. (4)
i. Store sheds—		feet.	f.s.
Spare parts	8	72×120	69,120
Tyres	6	72×120	51,840
Miscellaneous stores ...	6	72×120	51,840
Paint store	1	36×120	4,320
Total stores groups floor area	—	—	177,120
ii. Workshop group—			
Workshops	2	72×120	17,280
Packing case shed ...	1	72×120	8,640
iii. Receipt and issue departments	2	72×180	25,920
iv. Office buildings	3	28×120	10,080
v. Miscellaneous small sheds—			
Petrol and oil store ...	1	—	11,400
Fire stations	2	—	
Garage	1	—	
Guard room	1	—	
Air raid shelters ...	as required	—	
Decontamination hut		—	
Total other buildings floor area	—	—	73,320

Sheds, other than transit ones, should not exceed 120 ft. in length, and should be of standard span. A clear space of 50 ft. should be left round each building in order to minimize damage by fire or air attack.

3. **Construction.**—Owing to the great value of the stores, and to the serious consequences which would follow even their partial destruction, sheds should be non-inflammable. Standard steel-framed sheds with corrugated iron roofs and sides are suitable. The clear height to the eaves should be a minimum of 10 ft., to allow of stacking in bins up to that height.

The floors should be hard and dust-proof, those made of concrete being the most suitable. Wooden floors, unless solid, will not stand the weight, and other types are difficult to keep clean and free from grit and dirt, which cause excessive depreciation in the spare parts, etc., stored in the bins.

Magnetos, electrical equipment and other stores susceptible to deterioration through excessive heat, cold or damp, should be stored in an equable temperature, and this may involve special construction with brick or concrete walls, etc.

Good day lighting should be provided, preferably by north lights, and provision must be made for screening them when working by night.

A suitable arrangement of storage bins and racks is illustrated on Pl. **75**, and electric lighting should be arranged to suit this.

4. A lay-out for a tyre store is given on Pl. **76**, with suitable types of racks for tyres in Figs. 2 and 3 on the same plate. In tropical climates the tyre stores should be underground, if possible, to lessen the deterioration due to the heat.

5. Workshops should be provided for :—

i. the repair of part worn, repairable and unserviceable spare parts, equipment and stores returned to the depot by field and other units ;

ii. the repair of spare parts and stores held on charge of the depot.

iii. maintaining and repairing the vehicles on charge of the depot ;

In the early stages of a campaign this work will not be heavy, but in a war of any duration where large forces are engaged it will probably become necessary to establish a separate and self-contained retrieving workshop. The buildings and equipment for such a workshop are considered in Sec. **167.**

6. **Internal depot traffic.**—Broad gauge sidings are only required for the receipt and issue sheds. The internal movement of stores between the various sheds can be by tramway

or by hand trolley. No need for power trucks is visualized at present.

The plan on Pl. 74 indicates the tramway lay-out which would be required, necessitating some 2,050 yds. of track and 20 turn-tables.

As railway truck loads are made up of large numbers of articles from the different groups for various formations the consignments must all go through the packing and issue shed. The other sheds can be sited in positions best suited to the ground, subject to the observance of the safety distances given in para. 2, above.

7. **Water supply.**—A good fire fighting system should be provided as soon as possible, preferably in the form of a ring main enclosing the area covered by the buildings, with hydrants at every store building.

8. **Subsidiary buildings.**—Accommodation must be provided inside the depot for an adequate guard, a fire piquet and vehicle drivers. This can be in tents at the start, but accessories such as latrines and ablution places will be required.

9. **Fencing.**—The whole depot should be enclosed by a fence or wall to prevent the intrusion of unauthorized persons or enemy agents.

10. **Personnel camp.**—Owing to the sedentary nature of the work of clerks and storekeepers, the personnel camp should be not less than half a mile from the depot. The numbers to be accommodated will be approximately 14 officers and 164 men.

11. A suitable lay-out for a M.T. stores depot is given on Pl. 74.

A list of the major items of engineer material required for the construction of the depot is given in Appendix IX.

CHAPTER XXIII

R.A.S.C. DEPOTS (continued)—PETROL INSTALLATIONS.

122. Petrol supply

1. Unless there are storage facilities and other equipment for the receipt of petrol in bulk and its transfer to cans at the overseas base port, petrol will be shipped overseas in cans.

This method is uneconomical of labour and wasteful of shipping space (R.A.S.C. Training, Vol. II, 1933, Sec. **63**).

The construction of a bulk petrol installation (Sec. **123**) may therefore be required at an early date.

This is a lengthy business, and as a temporary measure it may be necessary to use a fuel tank ship (or barges) as a temporary floating petrol depot, equipping them with the necessary plant for transferring the petrol to cans.

2. The normal system of distribution of petrol to units in the field will be by cans, the petrol being transported to rail heads in cans and cases. If, however, suitable bulk fuel wagons are available, it may be advantageous to transport the petrol in bulk to railheads and to provide facilities for its transfer to small containers at these points (Sec. **124**).

123. Base bulk installations

1 The requirements of a base bulk installation are as follows :—

i. Fuel storage tanks, or reservoirs, sufficient to hold not only the authorized reserve and current requirements, but also spare capacity to enable fuel tank ships to clear their cargo at once.

Separate tanks will be required for aviation spirit and the various grades of petrol used in the field ; also for the mixing of spirit such as petrol benzol mixture when this operation is carried out at the overseas base.

In addition tank accommodation will be necessary for kerosene and possibly other oils.

Storage would usually be required on the basis

of three months' consumption by the force, plus 50 per cent. spare to enable fuel tank ships to clear.

ii. Pump, pipe lines and valves for intake and delivery.

iii. Can filling plant.

iv. A can and case factory, with plant for the manufacture and repair of cans and cases, also for the testing, cleaning and painting of cans.

v. Pipe lines for delivery into bulk fuel wagons or lorries.

vi. Railway sidings and road access.

2. A bulk petrol installation must be isolated from other base depots: and the storage tanks must be so situated that any large escape of petrol will not endanger any locality of military importance. If possible non-porous ground should be selected, lest in the case of excessive leakage it should become saturated, and so rendered highly inflammable.

A convenient lay-out for a base bulk petrol depot is given on Pl. 77.

3. Fuel storage tanks, for use in the field, will normally be built up of standard steel sections: these are preferable to concrete tanks in that they take less room, are quicker to construct, can be dismantled and will stand on comparatively poor foundations.

Standard tanks of varying capacity up to 8,000 tons are in commercial use. A common size is 50 ft. diameter by 30 ft. high—capacity, 1,200 tons (368,000 gals.); and, where the possibility of air attack must be taken into account, larger storage units are not desirable. Units of 4,000 to 5,000 tons are, however, far more convenient for a base installation holding 20,000 tons and upwards.

4. Intake is effected from fuel tank ships berthed alongside a special quay or jetty, provided with lines of 6 or 8-in. pipes with T-branches and non-return valves at intervals. Flexible armoured hose-pipes connect the pipe system on the ship to these T-branches. The ships' pumps of a tanker of about 8,000 tons will deliver about 250 tons an hour under favourable conditions: to pump 100 tons by hand takes about 30 hours.

If the head is greater than the ships' pumps can command the petrol must be forced by them to an intermediate station on shore, and from there by booster pumps to the reservoirs.

5. All necessary calculations can be made from the following table.

TABLE C.—DATA FOR PIPE CALCULATIONS

Petrol.		Diameter of pipe in inches.		
Tons an hour.	Gals. a minute.	4	6	8
		Loss of head in ft. a yard of pipe.		
(1)	(2)	(3)	(4)	(5)
50	250	0·2511	0·033	0·008
70	350	0·4923	0·065	0·015
100	500	1·004	0·132	0·031
150	750	—	0·298	0·069
200	1,000	—	0·529	0·126
250	1,250	—	—	0·197

For petrol 3-ft. head is equivalent to 1 lb. pressure per sq. in. On no account should the pressure on the delivery hose exceed 50 lb. per sq. in. when pumping spirit. If storage tanks are on a higher level than the ship's discharge the static head additional to the height of liquid in the tank (usually 35 ft. maximum) must be taken into consideration.

6. When it is impossible to pump direct from ship to shore owing to insufficient water or quay accommodation, or when it is required to divert part of the cargo, fuel tank barges (capacity 80 to 150 tons) may temporarily be used as the intermediary link.

7. During sea-transit special tanks are allocated to aviation spirit and Benzol mixture for tanks and dragons, and at the base definite tanks must be allocated permanently for their storage with separate pipe-lines and can-filling plant. In some cases the preparation of P.B. mixture might take place at an overseas base. If necessary, *e.g.* to avoid duplication of a large petrol intake system for the sake of a comparatively small supply of other spirit, petrol pipes, if they will not drain sufficiently well, can be flushed out with the higher grade spirit (which can then be run into the lower grade tanks) for the admission of other spirit: but it is very important to keep aviation spirit free from any possibility of contamination by other spirit or water.

8. If any petrol installation is to work successfully, the greatest stress must be laid on the necessity for not merely very good but perfect joints in the pipe lines: also the number of stop valves should be reduced to a minimum.

9. Delivery is effected by pumping from the reservoirs to elevated storage tanks, whence the petrol can be gravitated

as necessary to the bulk fuel wagons or lorries or to the can-filling plant.

The location of these storage tanks will depend on the siting of the depot and railway sidings in relation to the reservoirs: it may be found more economical to pump through pipe lines up to half a mile long than to bring the sidings or depot closer to the reservoirs.

Rail access must provide for the daily filling of bulk fuel wagons, the loading of tins and the return of empties. The types of bulk fuel wagon in commercial use have capacities varying from 2,000 to 4,000 gals. Road access must include accommodation for filling road tank wagons and for loading or unloading tins: bulk fuel lorries are now made with capacities up to 2,500 gals., but, if the roads are weak, it may be impracticable to utilize lorries of over 900 gals. capacity.

10. Can-filling plant is made up in standard units consisting of an overhead tank of 300 or 600 gals. capacity, to which petrol is gravitated from the storage tanks, a group of 4 or 8 automatic 2 or 4-gal. filling measures, and a small dump tank under the filling bench to receive waste petrol. The maximum output is about 40 2-gal. cans per filling measure per hour.

Non-returnable 4-gal. tins were largely used in France and almost exclusively in the Near Eastern theatres of war.

Pl. **77** shows a typical lay-out for a small installation, embodying the principles outlined in this section.

124. Forward bulk installations

1. These, when replenished by siphoning from bulk fuel wagons or lorries, entail less wastage and quicker refilling than from cans, while they occupy less space and are more easily controlled.

2. Such installations comprise a fuel storage tank, or a series of tanks, sunk either completely underground or partly underground with the excavated earth mounded over them, and a hand pump for filling road vehicles.

3. The largest standard tank (of riveted sections) which can be moved complete by rail (4 ft. 8½ in. gauge) is 9 ft. diameter by 30 ft. long—capacity, 12,000 gals., weight empty, 4 tons, full 44 tons. This also represents the maximum capacity which should be located at one point, having regard to the danger from air attack. Tanks 9 ft. diameter by 20 ft. long—capacity, 8,000 gals., are also in commercial use.

4. For temporary installations, however, smaller tanks (welded) with capacities from 500 to 3,000 gals. are more suitable, and Pl. **78** shows an installation of this type.

5. The capacity of cylindrical flat-ended storage tanks can be determined approximately by the formula :—

Capacity in gals. $=$ length $\times$ diameter^2 $\times 5$, both length and diameter being measured in feet.

To convert gals. to tons, in the case of petrol divide by 300.

6. The capacity of pipes can be determined approximately by the formula :—

Capacity in gals. per ft. run of pipe $=$ diameter^2 (in in.) $\times 0{\cdot}034$.

7. As a rule tanks should be sunk to such a depth that the top of the tank will be 2 ft. below ground level. In ordinary soil the excavation and placing of the tank is simple, the principal requisite being a level seating. Particular attention, however, must be paid to the presence of subsoil water or danger of flooding after heavy rains : in this case the buoyancy of an empty tank is such that adequate measures must be taken to preclude any danger of "floating." It is not sufficient to surround the tanks with loose soil or sand, but they must be securely anchored by wire rope to sleepers of reinforced concrete, or even timber, of sufficient area for the weight of superincumbent earth to counteract any tendency to rise (Pl. **79**).

8. Stand-pipes for refilling are not desirable, but automatic self-metering pumps having containers of 2, 5 or 10-gals. capacity of delivery should be installed.

The pump should be as near as possible to the tank.

The height (H) of the bottom of the pump pedestal above the bottom of the tank must not exceed 15 ft.

The length (L) of suction pipe, measured along the pipe from the bottom of the tank to the bottom of the pump pedestal, must not under any circumstances exceed the figure obtained from the following formula, and should not generally exceed 50 ft.

$L = 138 - 8H$ (L and H in feet).

Horizontal runs of suction, overflow and vent piping must be given as much fall back to the tanks as can be arranged up to 1 in 10.

The petrol is delivered from the container above the pump by gravity only. The height of the delivery outlet on the pump above the bottom of the pedestal varies from 5 ft. 6 in. with the twin-measure type to 8 ft. with the Bowser type. When this height is insufficient for supplying high lorries, etc., a suitable staging for the pump must be erected : where no such staging is necessary pumps are usually mounted on a concrete base not less than 1 ft. thick.

125. Can petrol sub-depot

1. An essential in the siting of any petrol depot or dump is that it must be situated sufficiently distant from the main supply depot or buildings to enable fire, should it occur, to be confined to the petrol depot.

A petrol dump will normally be subsidiary to a main or base supply depot, and it will be administered (much in the same manner as a section of the main supply depot) by its parent depot. Its highly inflammable nature alone necessitates isolation from dumps or stacks.

2. Before the construction of a sub-petrol depot is undertaken the possibility of utilizing any commercial installation existing locally should be explored.

3. Petrol may be dealt with either in cans and cases, barrels, or in bulk fuel wagons or lorries. In a prolonged campaign of any magnitude it may be received into the depot in bulk, and decanted into barrels or cans, and the manufacture of cans and cases may also be undertaken.

4. Petrol will usually be stacked in the open, but large open sheds are preferable, since the roofing provides protection in inclement weather for the handling personnel, and also some protection for the petrol itself. Below-ground-level stacking or the construction of fire-proof sheds will usually be found impracticable, but as soon as possible each petrol dump should be surrounded by an earth wall of sufficient height to confine the petrol in the case of a fire.

The best floor surface for petrol stores is sand.

The sheds or dumps should be served by double broad gauge rail tracks, as for supply depots, and there should be adequate loading platforms.

5. Petrol received and issued in cans and cases is dealt with similarly to other supplies from a supply depot point of view, and no engineering work peculiar to it is therefore necessary, other than a lay-out with isolated stacks, conformation of the ground being used in a similar manner to ammunition stacks.

Special means are, however, required for the handling of barrelled petrol, since a barrel, when full, weighs about 5 cwt. Runabout cranes, with a lifting capacity of 10 cwt. might be found suitable.

6. For a canned petrol depot, pending modification by bulk storage installation, Military Engineering, Vol. VIII, 1929, Pl. 5, gives the principles of a suitable lay-out for a force of 150,000 men, but with the increasing mechanization of the Army the acreage and tonnage quoted on the plate may be inadequate in any particular case.

The stacking area for petrol in cans and cases may be calculated at 3,000 tons an acre, or 300 tons gross an acre for depot area. Stacks should not be more than 5 cases high.

A 60 days' reserve for the force mentioned in Military Engineering, Vol. VIII, 1929, Pl. 5, might amount to 36,000 tons. This, at 3,000 tons an acre, will give a storage area of 12 acres, but, if an expansion factor of 10 is allowed for, to cover dispersion, double dispersal, space for returned empties, space for installations connected with the repair and manufacture of cans, and also for the filling and cleaning of cans, up to 120 acres might be required, or 300 tons gross petrol an acre depot area for canned and cased petrol and its salvage.

7. Office accommodation, etc., will be similar to that for a stores sub-section of the main supply depot, and telephone connection to the main supply depot switchboard is essential.

8. In addition to the storage of petrol in cans, a can petrol sub-depot will hold reserves and stocks of lubricating oils and grease. Sand floors should not be provided in the portion allocated to lubricating oils. Concrete and other impervious material is desirable.

CHAPTER XXIV

R.A.S.C. DEPOTS (continued)—COLD STORAGE INSTALLATIONS

126. General principles

1. The decomposition of perishable supplies can be delayed by storage at low temperatures. The provision of cold storage accommodation, therefore, enables troops to be supplied with rations which are not canned in hot climates or where lengthy storage is necessary.

Refrigeration may also be necessary in hot climates to lower the temperature of magazines, hospital wards and operating theatres, engine rooms, etc., and for ice production (Chapter XXIX).

2. Apart from living organisms such as fruit and vegetables, which are killed if the water they contain is frozen, in general the lower the temperature of storage the longer the life of the article stored. Frozen mutton, for instance, is practically imperishable, and when thawed shows little change from its fresh state. Beef, on the other hand, unless frozen very rapidly and thawed very slowly (the process taking at least 24 hours, and, better, 4 days) is spoilt by freezing, as it loses most of its moisture during thawing. Beef therefore, whenever possible, should be chilled but not frozen; but it is still perishable in the chilled state, in which its life, between killing and cooking, should not exceed 4 to 6 weeks, according to circumstances.

3. The limiting temperature below which ice crystals form in meat is 28·5 deg. F., and therefore the temperature of "chilled" stores should not be allowed to fall below 29 deg. F.

The minimum temperature for fruit stores is 34 deg. F. and temperature control must be accurate, as every degree rise may mean a shortening of the life of the fruit by 10 per cent.

Temperature control of fruit stores is also more difficult, since the fruit gives out heat in ripening, and there may be considerable difference between the temperature of the walls of the room and that in the middle of a stack. The latter should always be recorded and the difference should not exceed 3 deg. F.

4. Suitable temperatures for general purposes are 18 deg. to 20 deg. F. for frozen, and 35 deg. for chilled, stores. If further differentiation is possible, the following table gives suitable temperatures for various classes of stores.

TABLE D.—SUITABLE STORAGE TEMPERATURES FOR VARIOUS CLASSES OF PERISHABLE STORES

Commodity	Degrees F.
Apples	34–36
Bacon (mild cured)*	28–30
Beef (fresh)	32–36
,, (chilled)	28–32
,, (frozen)	18–20
Butter	Down to 0
Cheese	30–50
Chickens	18–22
Eggs	30–35
Fish (fresh)	25–30
,, (dried)	30–35
,, (S.W.) frozen	10–15
,, (salt) frozen	10–15
Fruit (fresh)	35–40
Game	18–22
Groceries and dried fruit	40–45
Ice	25
Liquids	35–50
Margarine	18–25
Milk (fresh)	32–36
,, (condensed)	35–40
Mutton (fresh)	32–36
,, (frozen)	14–18
Oranges	32–45
Vegetables†	34–40
Cordite	60

Thawing chambers should be kept at 32 deg. F.

Nitroglycerine freezes below 50 deg. F., and decomposes at about 70 deg. F.

5. The daily issue of perishable supplies to a force of 150,000 men may be estimated as follows :—

	Tons.
Beef (for troops and hospitals)	65–69
Bacon	14
Cheese	9
Mutton and poultry (for hospitals)	3–5
Margarine and butter (for troops and hospitals) ...	6
Total ...	97–103

* Bacon may also be hard cured and salt-packed. Cold storage accommodation would not then be essential.

† Vegetables will not usually require accommodation.

6. Supplies for a force of the size mentioned above operating overseas will not arrive in daily consignments, but in ocean-going ships, which will probably have to be unloaded rapidly and released for further voyages. Cold storage accommodation must, therefore, be sufficient for practically the whole of a cargo, which may amount to several thousand tons of meat. It will also be required for any reserve of meat which is ordered to be maintained, and this reserve for the force mentioned may amount to over 2,000 tons for a month's supplies. Allowing for a working margin storage for as much as 4,000 tons might be required for this force.

7. The storage accommodation should be situated at or near the waterside to assist rapid transference of frozen and chilled supplies from the ship. Before new construction is undertaken the possibility of utilizing any commercial installation that may exist locally should be explored.

Convenient means of issue to road, rail or other means of transport for consumption by the troops must also be considered.

The cold storage depot will be administered as a section of the main or base supply depot. Office accommodation will only be required for a small administering staff, and the personnel will, as a rule, be accommodated elsewhere, with the supply depot personnel if convenient: except for the engineer in charge, who should be accommodated on or near the premises.

8. An alternative system is that employed in Iraq in 1917–19. Supplies were then unloaded from steamers into refrigeration barges, each containing an ice plant in addition to cold storage accommodation.

The distribution of barges was so arranged that sufficient were at the base on the arrival of each store ship to unload her, while a few were at the advanced base unloading supplies for issue to the troops. There was also a fleet of 3 barges for collecting, cleaning, packing and freezing local supplies of fish. Supplies of meat on hoof were also purchased locally, and it was intended to freeze a portion of this to form a reserve.

9. For delivery of frozen or chilled supplies forward of the base, insulated transport by road, rail or water must be provided. In the case of long lines of communication it may be necessary to continue the refrigeration after the supplies have left the base. Barges or railway trains may carry their own refrigeration plants, but road transport may have to call in at cooling stations *en route* for refreezing, etc.

127. Buildings

1. It is desirable that cold storage buildings should be protected from direct sunlight in hot climates. To effect this they may be, partially at any rate, sunk below ground level, as at Malta; at Gibraltar they are tunnelled in rock.

2. Cold storage space may be reckoned at 100 cu. ft. to the ton for stacked stores. Individual store rooms should not as a rule exceed 10,000 cu. ft. in volume, giving a theoretical capacity of 100 tons each; but in practice 25 per cent. of the space must be left for inspection passages, cooling apparatus, etc., and in the case of stores for chilled meat which must be hung and not stacked, the capacity is greatly reduced. The chambers should not be unduly high, 8 ft. 6 in. being normally sufficient.

3. Separate issue, chilling and thawing rooms are desirable. To put warm stores into a cold store already partly full renders the maintenance of the desirable even temperature impossible, and it may therefore be necessary to chill the stores first in a separate compartment. Thawing may take place automatically and sufficiently slowly during transport to supply depots. If not, thawing rooms of capacity equal to 4 days' supply should be provided.

4. Each store and room must be separately insulated and should be lit artificially and not by windows.

In commercial practice the buildings are designed in separate storeys, the coldest store being at the lowest level, and the thawing, receipt and issue rooms at the highest. Stores are then handled by cranes on receipt and issue, and lowered or raised within the building by lifts. Lifts or cranes of 10 to 30 cwt. capacity are adequate and economical. Such a building is normally impracticable under war conditions.

For a single storey building entrances should be at the ends of the stores. The ventilating passage outside a cold meat store may be useful for the storage of fruit, vegetables, etc.

5. Obviously the less air at outside temperatures that enters the stores the better. Any necessary passages connecting stores should be chilled, and electric light switches should be outside the entrances to the stores. Entrances and hatches should be tight-fitting, self-closing and as small as consistent with rapid handling. Particularly with single storey buildings entrances should be double to provide an air lock. Heavy meat carcases should be hung by trolley hooks on to rails, which are continued through the doorway into the passage outside.

6. The greater the thickness of insulation the less the leakage of heat into the stores, and therefore the less the power necessary to maintain the low temperatures.

The most practical insulation material is slab cork: of this at least 6 in. are normally necessary, with more on outside walls exposed to the sun. Slag wool (silicate cotton) is a slightly better insulator, but is not so satisfactory or convenient, even when made up into slabs on a plaster or wire netting base. Granulated cork, charcoal, sawdust and similar loose materials should not be used. Onazote or cellular rubber has recently been introduced as an insulating material and appears to be satisfactory.

Magazines must be insulated with slag wool on account of the danger of fire.

Sawdust, if used, should be at least 12 in. thick, and 9 in. of other types of insulation are desirable. It should be contained between walls of T. and G. boarding, lined with waterproof paper or felt.

All parts of the stores including the doors and columns must be insulated.

The best form of pipe lagging is moulded cork lagging, but it is expensive; slag wool in a form to wrap round pipes is a satisfactory substitute. Failing these the pipes should be wrapped with at least 2 in. of rope lagging.

Pipes should not be boxed in wood but must be protected from damage.

7. Supplies should be stacked in blocks with passages round to give free air circulation. Dunnage also is essential: that on the floor should be movable and the floors should be concrete laid to a fall to one corner and drained. Dunnage of 2 in. vertical battens 9 in. apart should be fixed to the walls all round the store.

8. Hospital buildings which are to be cooled should be designed similarly to cold stores with a central passage closed in at the ends.

9. Construction materials which would be available in an overseas theatre of war may comprise one or other of the following:—

Timber, brick or concrete.

The conductivity of brick or concrete in comparison with that of compressed cork is as follows:—

10-in. brickwork is equivalent to 1-in. compressed cork slab.

15-in. concrete is equivalent to 1-in. compressed cork slab.

Brick or concrete buildings, unless of abnormally solid construction, require therefore much the same insulation as timber ones.

Typical construction and insulation of a frozen meat store built in timber is illustrated on Pl. **82**, Fig. 1.

If the store is built in brick or concrete, 5 in., or preferably 6 in. (in two 3-in layers), of compressed cork should be applied to the external walls.

The first layer could be put up in cement directly on to the brickwork or concrete, and the second arranged to break the joints in the first, also in cement, and secured to the first with cane skewers.

Alternatively granulated cork or silicate cotton may be used, and these may be retained behind tongued and grooved boarding.

Partition walls need not have more than 4 in. of compressed cork insulation, or an equivalent thickness of other material.

In brick or concrete buildings party walls may be of timber studding, if suitable constructionally; in which case compressed cork slabs may be inserted between the studs and rendered both sides with cement, or the studding can be boarded on either side and the interior space packed with granulated cork or silicate cotton.

10. A lay-out of a cold storage depot of 2,000 tons capacity which might be constructed under active service conditions is given on Pls. **80** and **81**.

An insulated hospital ward is illustrated on Pl. **82**, Fig. 2.

128. Power

1. The power required will vary with the efficiency of the plant, the quantity of supplies to be stored, the difference between the storage temperature and that at which the supplies are received, the amount of heat leakage into the store rooms, and the quantity and temperature of the water available for the condenser.

2. The problem as a whole is, therefore :—

i. To provide buildings to accommodate the maximum quantities of supplies and to permit the minimum of heat leakage.

ii. To calculate the heat to be withdrawn from the supplies on arrival and the daily leakage into the store: under the most unfavourable conditions afforded by the climate.

iii. To design and house plant to pump out the quantity of heat calculated in (ii) in 2 8 hour shifts; allowing 8 hours to rest plant, carry out minor repairs and give a margin.

3. The heat leakage is calculated in B.Th.Us. from the maximum estimated rise of temperature in 24 hours with the

plant stopped. At Gibraltar and Malta, in the hot weather with the engines stopped between 6 p.m. and 6 a.m., the maximum rise in temperature is only 4 deg. F. At Port Said, where the building is above ground and exposed to the direct rays of the sun, the rise was as much as 6 deg. in 14 hours.

For storage rooms of capacity from 1,000 to 50,000 cu. ft., from 50 to 100 B.Th.Us. per cu. ft. per 24 hours may have to be extracted.

4. The output of a refrigerating machine is most commonly stated in tons refrigeration, and the standard American ton of 2,000 lb. is employed as the unit of weight.

One ton refrigeration is then equal to 288,000 B.Th.Us. per day of 24 hours, or 12,000 B.Th.Us. per hour. It is the equivalent of the B.Th.Us. absorbed by 2,000 lb. of ice at 32 deg. F. melting to water at 32 deg. F.

It should be borne in mind, therefore, that a plant of 1 (American) ton of refrigeration capacity is not capable of producing 1 (English) ton of ice under the same conditions in the same time, but is only capable of producing roughly ½ (English) ton, *i.e.* 1,120 lb. of ice from water at 65 deg. F.

Usually the capacity of refrigerating plant is such that it is only necessary to run it for 8–12 hours out of 24 hours.

Small ice plant is also designed for 12-hour working to save personnel, though in the case of larger plants 24-hour working gives more economical results.

5. Example :—Take the case of a cold store holding a reserve of 1,000 tons which rises 5 deg. in 14 hours, and which has to receive a further cargo of 1,000 tons, and lower it from 30 deg. F. to 20 deg. F. in 30 hours.

i. Taking the specific heat of frozen meat to be ·4.

The heat required to be withdrawn per hour from the reserve $=1{,}000\times 2{,}240\times \cdot 4\times \frac{5}{14}=320{,}000$ B.Th.Us.

ii. The heat to be withdrawn from each new cargo as it arrives $=1{,}000\times 2{,}240\times \cdot 4\times \frac{10}{30}=298{,}667$ B.Th.Us.

This is less than the refrigeration required after the lower temperature is reached.

The total refrigeration will then be $2\times 320{,}000$ B.Th.Us.
+say 60,000 for loss through hatches, lights, etc.
=700,000 B.Th.Us. per hour.

or $\frac{700{,}000\times 24}{288{,}000}=58{\cdot}3$ tons of refrigeration.

Allowing an average figure of 2 B.H.P. (power to drive) per ton refrigeration, the total power required will be 116·6—say 120 B.H.P.

This assumes that the plant will be working continuously through the 24 hours. With an 8-hour rest in the 24 hours, the power required would be increased to 180 B.H.P.

For 9-in. brick and 9-in. slag wool between papered boards, heat leakage is about 1 B.Th.U. per 24 hours per sq. ft. per degree temperature difference. Leakage from pipes covered with 2-in. slag wool is 7 times this rate.

6. There may be a tendency to operate for an unnecessarily long period daily. Plant is designed for a specific performance, for example to maintain a temperature of 15 deg. F., and when some such temperature as 13 or 14 deg. F. has been attained, continuing operation produces little more effect. The reason for this is that the temperatures recorded are temperatures of the air; these may vary within 6 deg. or 7 deg. for short periods, whilst the mass of meat actually remains constant at (say) 15 deg. When the air has been lowered 2 deg. to 3 deg. below the temperature of the meat, transfer of heat from the meat will begin. Attempts then to lower the temperature (of the air) to a further extent mean trying to reduce the temperature of the mass of meat below its "standard" temperature.

On the other hand, when a fresh consignment of meat is received, it will be necessary to reduce its temperature to the standard temperature; and its temperature is not revealed altogether by the air temperature. It will usually be necessary then to operate on the chambers concerned for a continuous period of 36 hours to 72 hours. The *rise* of temperature during hours when the engines are stopped is the clearest indication whether the meat has or has not been lowered to the required temperature.

129. Refrigerating plant

1. The commercial refrigerating agents are:—

i. **Carbon dioxide.**—This is cheap, and leakage is not dangerous if confined to small quantities. For marine work CO_2 machines are used in large sizes, owing to the danger of ammonia leakage. The pressures required to liquify it are however high—750 lb. per sq. in. at 50 deg. F., and 1,000 lb. per sq. in. in tropical climates at 82 deg. F. It requires therefore heavy compressors and piping, and leakage is difficult to prevent. On land it is only suitable for small sizes or where space is limited.

ii. **Anhydrous ammonia.**—This is the commonest agent and the most suitable for general military purposes. The pressure required is moderate—160 lb. per sq. in. at 82 deg. F.—but large quantities

are required and leakage is troublesome. The gas is pungent and poisonous, tainting foodstuffs and attacking some metals.

iii. **Sulphur dioxide.**—This requires lower pressures still —62 lb. per sq. in. at 82 deg. F.—and leakage is unlikely to occur, but the gas is pungent, dangerous and destructive. Large quantities are required per ton of refrigeration. It is useful for portable plants, as the compressor should not give trouble.

iv. **Methyl chloride.**—The pressures required are only 18 to 30 lb. per sq. in. The gas is harmless but very inflammable, and trouble is apt to occur owing to the choking of the regulating valve by the formation of ice crystals from water in solution. It appears to be reliable and very suitable for small light machines, up to 2 h.p., or thereabouts.

v. **Ethyl chloride.**—Mixed with a small proportion of Methyl chloride. This is similar to the methyl chloride process, requiring similar low pressures, and is suitable for small sets up to 2 h.p., or thereabouts, but is now getting out of date.

2. i. Refrigeration will normally be effected by the compression system. The absorption system is either uneconomical or requires bulky machinery, except by the use of hydrogen—as in **electrolux** plant—which requires careful proportioning. Where cold air circulation is required, as for hospitals, it will normally be obtained with the use of a brine cascade and not by the air-expansion system.

ii. In small portable installations refrigeration may be effected by the direct expansion of the agent in evaporator coils in the cold store or ice tank. More frequently the evaporator coils will be immersed in a brine tank and the cooled brine circulated by a pump coupled to the refrigerating pump, through pipes to wherever it is required.

Ammonia plant especially should not be in close proximity to cold stores or ice tanks.

With NaCl, brine (1 lb. of NaOH to 100 lb. of salt) should be added to prevent corrosion.

iii. The direct expansion system is used in large installations for one class of goods, *e.g.* frozen meat. The limitation of direct expansion is that it is unsuitable for large variations in temperature. Moreover, interconnected circuits are all the same pressure, so that brine circulation is preferable if different temperature is essential.

3. Where brine is used its strength should be approximately 1 per cent. by weight of salt for every deg. F. below freezing-

point that the brine is to be lowered. If the brine is to be at a lower temperature than 5 deg. F., a solution of calcium chloride is necessary; for higher temperatures common salt may be used. Normally $3\frac{1}{2}$ lb. of commercial $CaCl_2$ is used per gallon.

The brine should be cooled by not less than 120-ft. run of $1\frac{1}{4}$-in. evaporator piping in the brine tank per ton of refrigerating capacity. The brine must be circulated by a pump at a speed not faster than 1 ft. per sec. through pipes fixed to the walls or ceiling of the cold store.

For chilling rooms, 1-ft. run of 2-in. pipe is required for 13 to 14 cu. ft. of space in case of direct expansion, or for 7 to 8 cu. ft. of space for brine circulation.

For storage rooms, these figures can be increased to 45 to 50 cu. ft., and 15 to 18 cu. ft. respectively.

For freezing rooms, they should be reduced to 6 to 10 cu. ft. and 3 cu. ft. respectively.

For accurate temperature regulation the piping should be split into independent coils of not more than 125-ft. run each for freezing stores, or twice that length for chilled stores, thawing rooms, etc.

A large number of small cooling coils give better results than a few large ones.

4. The air-circulating system renders stagnant layers of air unlikely and produces better ventilation, but, if the air is blown through a brine cascade, the brine gradually gets weaker and requires reconcentrating, and the plant will have to be run for longer periods than when brine with its high specific heat is used for cooling directly. This method avoids the trouble due to snow on brine pipes or fog in the cold stores and is suitable for fruit stores, hospitals and magazines.

Air should be delivered at the top of the store and drawn off through the walls; the quantity required is about 15 cu. ft. per min. for every 100 cu. ft. of storage accommodation.

Air ducts should be about 1 ft. square and should deliver air through 1-in. holes distributed along their length.

Warm air should be drawn off by similar ducts, and that from the colder chambers may subsequently be used to cool the warmer rooms.

5. Electric or I.C. drive is preferable to steam, and the compressor for military purposes should be of the vertical multi-cylinder high speed type. The design should provide for reversal of the compressors, so that they may pump out of the condensers into the evaporator in case of a leak in the former. All plant should be duplicated or designed to run in two halves in case repairs become necessary.

6. Other points to be observed are :—
   i. Ammonia must not come into contact with copper or its alloys.
   ii. The piping must be strong enough for the working pressures.
   iii. All joints must be metal to metal.
   iv. Non-freezing lubricating oil is required, and an oil separator must be inserted on the pipe delivering compressed gas from the compressor to the condenser.
   v. The high pressure delivery pipe from the compressor should be connected to the condenser, so that the gas flows in the opposite direction to the cooling water, *i.e.* to the bottom when cooling water is sprayed in from the top, the hotter incoming gas thus first meeting the hotter outgoing water.
   vi. Special valves of the back seating type should always be used, as, when they are fully open, there is an excellent gas-tight joint which does not rely on a stuffing box.

CHAPTER XXV

OTHER DEPOTS

130. Ordnance depots

1. Ordnance depots comprise base and advanced depots, and ammunition depots.

The latter are considered in Sec. **132.**

2. A base ordnance depot comprises :—

i. The offices, including the central provision office.

ii. The stores depot, including gun and vehicle park.

iii. The returned stores depot.

iv. The workshops.

(Ordnance Manual (War), 1931, Sec. **35.**)

Diagrams showing ideal lay-outs are given in Military Engineering, Vol. VIII, 1929, Pl. **6,** for railway lay-out, and in Ordnance Manual (War), 1931, Appendix VI, Pls. **1** to **6.**

These allow for a force of 6 divisions with space for expansion to 20 divisions.

As the plates in Appendix VI give details of buildings, roads, etc., which will be required, they are repeated in Pls. **83** and **84** of this volume.

3. Ordnance stores other than ammunition are classified in eight groups and the covered storage accommodation required for each group is given in the following table (extracted from Ordnance Manual (War), 1931, Sec. **39**).

Table E.—Covered Storage Accommodation required in Base Ordnance Depot

Group	I.	Equipment, rifles, etc. ...	30,300	sq. ft.
,,	II.	H.T. vehicles, harness, etc. ...	29,000	,,
,,	III.	Tools, materials, paint, etc. ...	22,500	,,
,,	IV.	Barrack and camp stores ...	17,400	,,
,,	V.	Guns	44,800	,,
,,	VI.	Engineer and signalling equipment	41,800	,,
,,	VII.	"A" and "B" vehicles ...	78,100	,,
,,	VIII.	Clothing	12,100	,,
			276,000	,,
Reserves for special services			24,000	,,
Transit shed			40,000	,,
		Total	340,000	,,

This accommodation is provided in eight main store sheds, each 380 ft. by 110 ft. (excluding platform shelters), giving a total of 334,000 sq. ft., which will suffice.

The returned stores depot requires a further 65,000 sq. ft. of covered accommodation (para. 13, below) and the workshops a further 493,000 sq. ft. (Chapter XXIX).

4. These figures give the covered accommodation required for 6 divisions on the basis of four months' working stock. Expansion to meet the requirements of a larger force will be in accordance with the table in Sec. **117**, 6.

The requirements of ordnance workshops are considered in further detail in Chapter XXX.

5. **Miscellaneous yard and other buildings.**—In addition to the actual stores buildings, the following buildings will also be required (Ordnance Manual (War), 1931, Appendix VI).

		ft. ft. ft. in.
i.	Timber rack, roofed	70×30×10
	Metal rack, roofed	100×10× 6 6
	Cemented oil yard	80×80
	,, ,, ,, —drainage oil pit	3× 3× 3
	Oil store (concrete floor)	40×25
	Inflammables store (no timber) ...	25×20
	Acid store (wooden)	30×10
	Petrol store	as required

ii. On the main road along one side of the depot, near the administrative offices :—

	ft. ft.
Guard room	30×20
Emergency party hut	40×20
Yard office	20×12
Orderly officers' hut	12×12
Fire engine and fire brigade hut ...	36×20

iii. Between the 1st and 2nd sheds, *i.e.* central :—

	ft. ft.
Traffic office	40×20
Traffic store	20×20
Movement control office	20×16

iv. Between the 1st and 2nd sheds or at their outside ends :—

	ft. ft.
Wheel racks	126×30
,, ,, ...	300×30

6. **Office accommodation :—**

i. Head offices will be required for about 25 officers and 150 clerks. They should be sited in the most central position in the stores depot.

The area required is as follows :—

Office.	No. of rooms.	Area f.s.
A.D.O.S.P.	24	8,400
C.O.O. and Indents	9	3,400
O.O. and Accounts	6	2,300
	Total	14,100

These offices should be of standard type (28 ft. span) as illustrated in Pls. **15, 23** and **24,** and should be in two or three blocks adjacent to each other as best suited to the site.

ii. Group offices will be required for each of the eight groups. These can be either inside, or semi-detached, at one or both ends of the four store houses adjoining the line on which the wagons for the pack train are loaded.

For each group except No. VII they should be 600 f.s. in size, and divided into two.

For No. VII group the office should be 4,800 f.s. divided into eight rooms.

7. **Construction.**—Main stores buildings will be 108 ft. (nominal) wide, built up of three 36-ft. spans and of standard construction as shown on Pl. **72.** The maximum length of any building should not exceed 400 ft.

The floor surface of the sheds and platforms must be hard and strong enough to carry heavy stacks of stores; and internal traffic ways must be smooth. Concrete is the best, but tarmac, if well laid, is suitable.

Ample lighting must be provided, both by day and night.

8. **Internal traffic.**—Where a regular flow of traffic along fixed lines within the depot is to be anticipated a tramway system can be installed; and, where advantageous, this can be supplemented by gravity rollers or other conveyor systems.

Stores for pack trains will normally be conveyed in barrows, mechanically operated, if possible.

Stacking spaces between sheds should be surfaced with tarmac, and gun and vehicle parks must be capable of supporting heavy wheeled vehicles.

Commercial types of conveyors are considered in Chapter XXXIII.

9. **Yard appliances.**—End and side loading platforms and ramps, and gantries suitable for dealing with heavy guns, carriages, tanks, and M.T. vehicles, will be required in the gun and vehicle park.

One 10-ton and one 5-ton locomotive crane will be required in the vehicle park, and two 30-cwt. travelling cranes in the stores depot. Two 30-cwt. travelling gantries will also be required in the returned stores depot.

10. **Dunnage.**—Large quantities of timber dunnage will be required for stacking stores. Any timber with parallel sawn sides will do, but 2 in. × 1½ in. is the most useful size, and some 100,000 ft. run of this is likely to be required.

11. **Racks.**—The R.A.O.C. will normally provide metal racks for use in store sheds. If these are not available, some

100,000 ft. run of suitable timber would be required for the purpose.

12. **Loading platform.**—As time and labour permit a platform at wagon floor level should be provided to facilitate loading stores for pack trains.

13. **Returned stores depot.**—The returned stores depot and workshops work in close connection with each other and are, therefore, normally sited side by side.

The covered accommodation required for a force of 6 divisions, is given in the following table (Ordnance Manual (War), 1931, Chapter IV).

TABLE F.—COVERED ACCOMMODATION REQUIRED IN A RETURNED STORES DEPOT

Receiving	8,000 f.s.
Sorting	14,000 ,,
Brushing web equipment	3,600 ,,
Breaking down, etc.	3,600 ,,
Cleaning leather	3,200 ,,
S.A.A.	1,300 ,,
Boots	5,600 ,,
Tent repairs	8,000 ,,
Tent drying	2,700 ,,
Camp kettles, etc.	4,500 ,,
Clothing	10,000 ,,
Total ...	65,000 ,,

Shedding will be of the same standard design as store sheds.

An office block approximately 30 ft. by 28 ft. will also be required.

14. **Roads.**—The amount of road which will be required will depend on local conditions. Although, in most cases, depot working will be almost entirely by broad gauge railway this may not always be so, and road communication will always be required to offices and to gun and vehicle parks. In extreme cases roads may be necessary to all store sheds, as indicated on Pl. **83.**

Where provided they must be solid, and wide enough to take all the traffic likely to use them.

The amount of road which might be required under the most unfavourable conditions in a depot for 6 divisions would approximate to 11,000 yds. run of 30-ft. wide road; and the transport of the necessary road material and its construction would make a heavy call on engineer resources.

15. **Protection.**—The risks of fire resulting from attack by aircraft must be guarded against. In extreme cases G.H.Q. may even decide that a depot must be divided to lessen the danger.

In many cases stores may have to be grouped in alternative stacks of inflammables and non-inflammables, and, where possible, traverses should be erected to localize the effects of a fire.

Protective arrangements for men in the form of shallow trenches and, if possible, dug-outs, should be scattered about the depot.

There should also be an ample water supply with fire mains (4-in. or 6-in.) along all sheds.

A fire engine shed should be provided, as stated in para. 5, ii, above.

16. **Accommodation for personnel.**—Accommodation will be required for 2,800 officers and O.Rs., and a labour camp for 750 men will also be required; these totals include workshops.

Camps should be outside, but convenient of access to the depot.

17. A list of the main items of the materials required for the construction of an ordnance base depot is given in Appendix IX.

131. Advanced ordnance depots

It is impossible to lay down any scales of provision for advanced ordnance depots, as these will depend on the circumstances in which the advanced depot has been formed (Ordnance Manual (War), 1931, Sec. **1**).

The lay-out will follow the same general lines as that for a base depot, but will normally be on a very reduced scale.

The advisability of a duplication of ordnance workshops is a matter which will require very serious consideration, but it may become necessary to undertake certain classes of repair work almost entirely at the advanced depot.

Ordnance Manual (War), 1931, Appendix VIII, Plates 1 and 2, gives lay-outs for advanced depots which may become necessary under extreme conditions (*see* Pl. **84**).

Under such conditions covered storage of 170,000 f.s. may be required, with a further 32,700 f.s. for the returned stores depot. Construction and other engineer work will be on similar lines to that for a base ordnance depot.

132. Ammunition depots

1. **General.**—In view of the scale of air attack which may be encountered schemes for the installation of ammunition depots require careful consideration. As ammunition offers such an attractive target to air attack, and the results of an explosion may be so disastrous, certain principles for the siting and lay-out of ammunition depots must be laid down, and adhered to rigidly. This section embodies the provisions of Magazine Regulations; but, at least in the early stages of a campaign, local conditions will probably necessitate modification of the type of construction here detailed; for instance, the provision of heavy splinter-proof sheds must necessarily await

adequate supplies of labour and material. The general lay-out, however, should conform to the principles laid down in this section, and sites for temporary dumps of ammunition should be prepared clear of the sites where splinter-proof sheds will eventually be built.

2. The amount of ammunition of various categories to be stored in a depot will depend on the nature of the operations, and on the theatre of war, but for purposes of calculating storage the following table can be applied :—

TABLE G.—STORAGE SPACE FOR AMMUNITION

Category.	Group.	Description.	Gross stacking space (including gangways, working space, etc.)	Dead weight of stack 10 ft. by 10 ft. by 7 ft. high (Mag. Regns., Part II, Appx. II).
(1)	(2)	(3)	(4)	(5) (Average)
A.	Boxed ammunition (Q.F.)	Q.F. for field guns and howitzers.	1 ton a sq. yd.	18 tons.
		S.A.A.		23 tons.
B.	Component ammunition (B.L.)	Plugged shell. For Medium and Heavy Arty.	1 ton a sq. yd.	18 tons.
		Cartridges. For Medium and Heavy Arty.		8 tons.
		Fuzes and tubes. For Medium and Heavy Arty.		13 tons.
C.	Bombs and grenades.	Including aerial and mortar bombs.	0·6 ton a sq. yd.	13 tons.
D.	Miscellaneous ammunition	Incendiary and smoke ammunition and pyrotechnics.	0·6 ton a sq. yd.	13 tons.
E.	Demolition explosives.	—	0·6 ton a sq. yd.	12 tons.

S.A.A. may be stored with any category, but should be distributed as far as possible.

The figures in column 4 allow for the necessary working and sorting space; in calculating the number of bays for any given quantity of ammunition from column 5, allowance must be made for the spaces occupied by traverses, cross-bracing, gangways and working space.

3. **Covered accommodation.**—The covered storage accommodation required in a base ammunition depot to hold 10,000 tons and 38,000 tons respectively are given below; requirements for intermediate tonnages can be worked out proportionately, but 38,000 tons is the maximum tonnage which may be stored in any one depot for safety reasons.

Sheds.	10,000 tons.					38,000 tons.				
	Categories.					Categories.				
	A	B	C	D	E	A	B	C	D	E
300 ft. × 30 ft.	6	2	—	2	—	21	6	—	6	—
100 ft. × 30 ft.	—	4	—	—	—	—	12	—	—	—
20 ft. × 30 ft.	—	4	—	—	—	—	12	—	—	—
16 ft. × 25 ft. (in groups of 10)	—	—	20	—	12	—	—	60	—	40

The original lay-out must allow for expansion to the maximum requirements (38,000 tons), in accordance with the regulations given in the following sections.

A lay-out for a base ammunition depot as above is given in Military Engineering, Vol. VIII, 1929, Pl. 7.

4. **Site.**—The principal factors governing the choice of a site for an ammunition depot are :—

i. Isolation from other depots and habitations. To protect the civil population the distance between munitions sheds and the nearest inhabited places should be not less than :—

1,100 yds. in the case of trench munitions and bombs.
700 yds. in the case of other munitions.

Exceptions may be made in the case of isolated houses.

ii. Necessity for ample area to allow of adherence to the principles governing lay-out (para. 5, below).

iii. Accessibility by rail, and facility for rail communication within the depot area ; the main line must be outside the area liable to damage by explosion.

Advantage should be taken of any features of the ground in siting sheds, so that they may be traversed from each other by any hillocks, banks, trees, etc., that may exist.

The handling of heavy bombs and shell will be greatly facilitated where the conformation of the ground admits of shed floors being level with the floors of wagons on the loading line, without involving excessive earthwork.

5. **Lay-out.**—i. Pl. **85** shows diagrammatically the size of sheds and the safety distances which should exist between them.

If any stack of ammunition is in the open it should be regarded as a shed for determining safety distances.

ii. All ammunition with the exception of plugged shell and S.A.A. should, as far as possible, be stored in splinter-proof sheds. Light weather-proof sheds give sufficient cover for plugged shell and S.A.A.

iii. Sheds should not exceed the dimensions shown on

Pl. **85** (trench munitions, *see* para. 8, below). In forward areas sheds smaller than 300 ft. by 30 ft. are usually more suitable.

iv. The following minimum distances should be maintained :—

(*a*) 100 yds. between the ends of adjacent sheds. If the sheds are not traversed these distances should be doubled.

(*b*) 400 yds. between lines of sheds of the same category. Where it is impossible to obtain sufficient space this distance may be reduced to 200 yds. on the line of communication and 100 yds. in forward areas.

(*c*) 400 yds. between lines of sheds of different categories.

(*d*) 400 yds. clear between arrival or departure sidings and any munition shed or loading line.

v. For component ammunition, cartridges and fuzes should be stored separately from the shells, the tube and fuze stores being 130 ft. from the shell shed and 50 ft. from the cartridge sheds (Pl. **85**, Fig. 2).

Incendiary and smoke ammunition should be stored in separate sheds as far apart from each other as practicable, fireworks, etc., being stored in the intermediate sheds.

vi. A covered transit platform lightly roofed will be required for the component ammunition group, 300 ft. by 30 ft., with the floor at wagon floor level.

vii. Typical lay-outs for ammunition depots are given in Military Engineering, Vol. VIII, 1929, on Pl. **7**.

6. **Sheds.**—

i. **Heavy sheds** should be provided for all munitions other than plugged shell and S.A.A. They can be rendered splinter-proof by covering the roof with 15 in. of sand and by surrounding them with traverses (*see* para. 7 below).

ii. The great weight on the roof (168 to 194 lb. per ft. super.) necessitates solid construction on concrete block foundations, and heavy cross-bracing and end-strutting of the shed.

Suitable types of construction are shown on Pls. **87** and **88**.

The foundations should be of concrete slabs (1 to 6) 3 ft. square and 12 in. thick, with a depression about 2 in. deep to take the foot of each stanchion ; in marshy ground slabs should be 4 ft. square and tied by rails or R.S.Js.

The open fronts of heavy sheds should be protected by movable C.I. panels 10 ft. wide.

iii. **Floors.**—Shed floors should be levelled and laid with 3 to 4 in. of sand, gravel or similar material. For boxed ammunition and heavy shells, a firm and level floor is required, necessitating the provision of large quantities of timber as dunnage ; offcuts of trees, if they have parallel sawn sides, are the most economical form. As an alternative local bricks

may be laid flat on the sand surface, thoroughly soaked and grouted in, in which case only strips of light scantling will be needed to keep the driving bands of shells off the ground.

Where floor space admits heavy shells should be placed on end.

iv. **Height.**—A shed 8 ft. high from ground level to eaves will be sufficient for :—

(*a*) medium and heavy artillery shell;
(*b*) smoke ammunition of all kinds.

For all other ammunition (except trench munitions), the height should be increased to at least 10 ft. from ground level to eaves.

v. **Roofs.**—The flat pitch of the roofs, and the covering of sand which will not allow rainwater to run off freely, conduce to leaky sheds. To obviate this 2-in. strips of heavily-tarred felt should be inserted between sheet overlaps, which should amount to two corrugations for side, and 6 in. for end, overlaps.

vi. Where it is not possible to provide weather-proof sheds for medium and heavy shells, they should be protected, if possible, from the direct rays of the sun, and they should be given good ventilation, the object being to avoid amatol-filled shell being subjected to temperatures above 80 deg. F., which may affect their efficiency. In temperate climates this protection can be afforded by tarpaulins stretched over light wooden framework placed over the shell.

7. **Traverses.**—

i. Traverses should be constructed along the back and at the ends of every light or heavy shed, other than those for plugged shell. A detached traverse in front, overlapping the shed by 25 ft. at each end, should be located between the loading and running line, and cross traverses should be constructed inside the shed every 75 to 100 ft. of its length. Their object is to protect the interior from bombs falling just outside the shed, and from splinters and fragments projected from an adjacent burning shed; and also to restrict the projection of fragments and localize the damage if the shed itself takes fire.

ii. Pls. 85 and 86 show the general arrangement of traverses, which will normally be of corrugated iron sides filled between with earth or sand. The sheets of corrugated iron are riveted together along their edges and tied through the traverse with rods ~~or wire~~, so that, if the woodwork supporting it is burnt away, the corrugated iron will not collapse.

iii. Traverses should be nowhere less than 2 ft. thick, and should be carried up to the roof. Detached traverses should not be less than 10 ft. high.

Internal cross-traverses should be located as far as possible in cross-braced bays, to economize in stacking space. It is

important, however, that no wooden beams should pass through, as they might carry fire from one compartment to another.

iv. When the extent of ground space occupied by a traverse is not of importance a very good form is an earth bank with a slope of 1 in 1 which requires no revetting.

Sandbag traverses or walls with unprotected surfaces are apt to be damaged when ammunition is handled, and are unsatisfactory on account of the large amount of work necessary to keep them in repair. If, however, sandbag traverses are used for any reason, they should be properly bonded, and the slope of the sides should not be steeper than 4 in 1.

8. **Trench munitions and demolition stores.**—

i. For trench munitions, aerial bombs and demolition explosives, the standard stacking unit should not exceed 25 tons, stored on about 250 superficial ft. of floor space.

ii. Pl. **86**, Figs. 1 and 2 shows a typical arrangement.

Stacking units are arranged in groups of ten. A distance of 100 yds. clear should be maintained, both transversely and longitudinally, between groups.

iii. Where sheds of this type cannot be constructed an alternative arrangement is indicated on Pl. **86**, Fig. 3, where the contents of each shed must not exceed 200 tons, and sheds to hold 100 tons are preferable where there is room for them.

The sheds should be traversed all round, and have splinter-proof roofs.

9. **Laboratory and magazine area.**—

i. Operations, such as filling or internal examination of shell, cartridges, etc., are laboratory operations, which should be carried out as far as possible under "magazine conditions."

ii. The site of the operations should be at least 400 yds. from any stock of ammunition or other explosives.

The shed construction should be similar to that for trench munitions, not more than one dangerous operation being carried out in any one shed.

The area allotted should be fenced and under guard.

iii. A magazine must be provided at a distance from the laboratory to store the bulk of the explosive used. The magazine may consist of a group of sheds as for trench munitions, or of heavily-traversed splinter-proof sheds, 100 ft. by 30 ft.

Where natural features permit the magazines may be dug out in a hillside.

10. **Internal depot traffic.**—A tramway system in an ammunition depot, in addition to the broad gauge lines, may

give a great economy in the use of standard gauge trucks and of their movements for internal traffic. It is specially useful in the component area. The tramways should be laid between the sheds and the broad gauge loading lines.

Transporter systems such as gravity rollers also save much time in the unloading, stacking and loading of ammunition.

An ample supply of hand or, preferably, power driven trolley or barrows is also required.

11. **Fire protection.**—Owing to the large area occupied and the difficulty of approaching a shed which has once caught fire, an elaborate system of water mains is useless. Only first aid fire protection is of value. For the supply of water to fire buckets and hand pumps it will be necessary to provide 1,000-gal. tanks at each end of each shed ; where sub-soil water is close to the surface pumps will suffice.

12. **Lighting.**—

i. An ammunition depot should be lighted electrically, and, by reason of its isolation, will usually require its own generating station.

A suitable scale is one 25 c.p. lamp for each bay inside the shed, and one 25 c.p. lamp for every two bays under the eaves to light the loading platform. This necessitates 45 lamps for a 300-ft. shed.

Opportunity should be taken to light the personnel camps.

ii. The installation should admit of all lights :—

(*a*) in the ammunition depot ;
(*b*) in the railway yard ;

being immediately switched off on the approach of enemy aircraft.

13. **Miscellaneous.**—

i. **Accommodation for personnel.**—Accommodation will be required adjacent to the depot for the personnel and labour employed. Within the depot area itself fire picket and guard tents, latrines and incinerators will be required.

ii. **Boundaries.**—Where possible depots should be surrounded by a ring fence, about 5 ft. high, of posts with 4 or 5 strands of barbed wire, at least 50 yds. from any shed. The main object of this is to provide a line which the sentries can watch.

iii. **Camouflage.**—Effective camouflage is impossible as a whole, owing to the straight lines of sheds, the shadows cast by the sheds, and the lines of railway. Efforts should be directed towards rendering light and heavy sheds indistinguishable from each other when viewed from above.

Careful selection of the site may, however, make it difficult for an ammunition depot to be recognized as such from the air, until aircraft are nearly overhead.

Of all the ammunition depots in France in the Great War that among the sand-dunes at Dannes Camiers was the least visible and appears never to have been discovered by enemy aeroplanes.

14. A list of materials required for the initial construction detailed in para. 3, above, is included in Appendix IX.

133. Engineer store depots

1. **General.**—The functions of engineer store depots are laid down in the Manual of Engineer Services (War).

The stores to be held in a depot will depend on the theatre of war, its natural resources, and the nature and duration of the campaign ; it is not possible, therefore, to lay down any figures of stocks to be held, or of storage accommodation required, which will hold good in every case.

Unlike supplies and ordnance or M.T. stores, there is no fixed scale or establishment which must be maintained, and it will be one of the first duties of the Director of Works to decide on the types and quantities of engineer stores which will be required both as a first supply and as supplementary provision as soon as the theatre of war is known.

The local resources of the particular theatre of war have an important bearing on his decisions, as well as the possibilities of local production, either actual or potential.

In some cases this may have been established by engineer reconnaissance prior to the outbreak of hostilities.

To assist in the preparation of this list of stores a Vocabulary of Engineer Stores (War) is being compiled.

It may be taken for certain, however, that the longer the duration of the war the greater will be the reserves of engineer stores required to meet the needs of the force as a whole.

It is essential, therefore, to adopt from the outset a depot lay-out capable of expansion to meet all conceivable demands.

2. Military Engineering, Vol. VIII, 1929, Pl. **6**, gives the lay-out for an ordnance depot for 6 divisions and capable of expansion to serve 20 divisions, and a similar lay-out will meet engineer store requirements.

As with all stores depots, facility of railway operation is the ruling factor, and the site must be selected and a lay-out arranged with this in view.

3. As a guide to the tonnage of stores which may be required, Military Engineering, Vol. VIII, 1929, Sec. **4, 7,** gives a figure of 20 tons per division per day as the average tonnage of engineer stores required by the fighting troops in mobile warfare. These figures do not take into consideration the vast quantities of stores required for work in the base and line of communication area, road work, etc. ; in addition a large

increase must be envisaged should position warfare intervene,* or severe climatic conditions necessitate the provision of hutting on a large scale.

4. For convenience engineer stores are classified in groups, and the table below gives particulars of the stores which would be required for a force of 6 divisions as a first provision under normal conditions under their various group headings, together with the stacking areas and covered accommodation required.

TABLE H.—STORAGE ACCOMMODATION REQUIRED IN ENGINEER STORE DEPOTS

Group	Description.	First supply in tons.	Stacking area. f.s.	Covered storage. f.s.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)
I	Timber	4–5,000	100,000	—	Despatched in a shipload of assorted scantlings. This would be supplemented by local purchase.
II	Trench stores	—	—	—	The bulk of these would be manufactured locally as and when required.
III	Huts and hutting stores.	600	4,500	600	Supply will depend on the policy adopted on winter hutting. Cover required for fittings, bolts, and other small parts.
IV	Water supply plant and stores.	5,400	40,500	27,000	Two-thirds under cover.
V	Electric light plant and stores.	2,430	18,225	18,225	—
VI	Workshop and depot plant and stores.	750	5,625	5,625	—
VII	Bridges and bridging stores.	600	4,500	—	—
VIII	Tools, etc.	—	7,000	7,000	R.A.O.C. Supply.
IX	Defence stores	—	110,000	—	R.A.O.C. Supply.

Total covered storage ... ... 58,450 f.s.

* During the Great War position warfare requirements in France amounted to 2,000 tons per division per month, exclusive of other requirements.

5. In addition to the storage accommodation, the following buildings will be required :—

i. Headquarters.—Offices for 3 officers and about 12 clerks, approx. 1,500 f.s.

ii. Two section offices each for 3 officers and about 32 clerks, each approx. 2,500 f.s.

These should be in a central position and grouped in one building, or in three adjacent ones as convenient.

iii. Latrines and ablution places.

iv. Personnel camp for 9 officers and 215 O.Rs.

v. Civilian labour camp.—Up to 500 civilian labourers may be required.

6. **Construction.**—The store shedding will be of similar design to that for supply and ordnance stores, *e.g.* normally 108 ft. wide, built up of standard 36-ft. spans. Lengths of sheds will be as required to house the stores under cover, but should not exceed a maximum of 400 ft. for any one shed.

Sliding or roller doors will be required at 50-ft. intervals in long sheds.

Firm hard floors are necessary, and they should be as free from dust as possible in the circumstances.

Racks and bins will be required for small fittings, tools, etc.

7. **Lay-out.**—The railway lay-out allows for stacking areas 1,000 ft. long, each area served lengthwise by sidings at 170-ft. centres. Where large stocks of materials such as timber, bridges, and hutting are held, two or more stacking areas may be required for such groups.

To minimize fire risk, inflammable and non-inflammable stores should be placed in alternate stacking areas, and in the inflammable areas wide fire breaks should be left between stacks.

In certain cases it may be possible to supplement rail movement by inland water transport, particularly between port and depot ; facilities will be required accordingly.

8. **Internal depot traffic.**—The depot will normally be laid out for working by broad gauge railway, and internal roads are therefore unnecessary. It may often, however, be found necessary to issue to road vehicles, and this is best arranged by running out a siding for this purpose with good road access to it. This saves in the amount of road to be made, and the depot working is not upset by the road vehicles in the depot.

The nature of engineer stores does not lend itself well to mechanical methods of handling, and most stores will have to be loaded by hand into railway wagons, which must be shunted about the depot as required. Light runabout cranes

for machinery, etc., and a certain number of power-driven trolleys for general stores will be found useful. In the bridging stores area, where heavy sections may have to be handled, rapid loading and despatch will be greatly facilitated by increasing the number of sidings, thus bringing them closer, and by building large gantries with mechanically operated travelling cranes over them and the heavy bridging sections, which would be stored underneath ready for issue.

The nature of the operations and the type and number of bridges held in reserve will determine the necessity for this provision.

9. **Workshops.**—

i. Engineer base workshops will frequently be employed in the manufacture of articles for storage and general issue. This will be particularly the case with first supplies of approved articles, which may later be manufactured at home and shipped out to the theatre of war.

ii. Although it is a convenience to have base workshops close to the stores depot a clear demarcation of their respective functions is essential, and articles manufactured in base workshops must be transferred to the stores depot before issue.

The only exception to this is in the case of timber, where it will often be convenient and save handling to have a few portable and motor-driven ripsaws in the stacking area for the conversion of timber into various scantlings.

iii. Base workshops must therefore be connected by rail to the stores depot, and in some cases it may be a convenience to have a tramway laid as well, more particularly when there is a large and steady manufacture of some particular article, and a direct run from workshop to stacking area can be obtained.

It must be remembered, however, that a general system of internal depot working by a tramway superimposed on a broad gauge system is merely a nuisance in an engineer as in any other stores depot.

Engineer workshops are dealt with specifically in Chapter XXX.

10. **Water supply.**—Certain engineer stores, such as timber, hutting stores, etc., are highly inflammable, and their stacking areas should be ringed with a 4-in. fire main with hydrants at frequent intervals.

11. **Fencing.**—This is desirable, but not essential, but guards and watchmen must be provided.

12. **Personnel and labour camps.**—These should be in the near vicinity of the depot.

134. Transportation stores depots

1. Transportation stores depots may be required for railways, docks or inland water transport. Considerations of suitability of site will normally necessitate separate depots for each.

2. **Site.**—

i. For a railway stores depot the site will be governed primarily by its suitability for railway working. At the same time it is of convenience if railway stores and workshops can be close to each other. Further, the siting together of engineer and railway stores depots facilitates traffic working.

ii. Similarly, an inland water transport stores depot requires to be convenient of access to the navigable waterways which it serves.

iii. A separate docks stores depot will normally only be required in cases where a considerable amount of dock development and construction is necessary, and its siting is governed by similar considerations. In the case of a reasonably well equipped port stores for the normal maintenance and working of the docks will be accommodated in the railway stores depot.

3. The following paragraphs refer to the requirements of a railway stores depot. These will depend on the circumstances of the particular theatre of war, the gauge and type of track in existence, the extent of the L. of C., the amount of new construction necessary and the resources of the railways in that theatre.

4. **Lay-out.**—A type lay-out for a railway stores depot is given in Military Engineering, Vol. VIII. It provides accommodation for the storage of 100 miles of track, together with six months' supply of stores for the construction and operation of a line of communication, with the number of transportation troops and unskilled labour that would normally be allotted.

It should be noted that the extent of the railway equipment will not vary directly as the size of the force, but is mainly determined by the extent and nature of the line of communication and the number of transportation troops employed.

The lay-out is on the standard grid pattern, with pairs of sidings, at 20 ft. centres, to allow of crane working, 1,000 ft. long in the straight, and 170 ft. between the centres of tracks adjoining the stacking areas.

5. **Storage accommodation.**—Railway stores are divided into groups. Considerations affecting the storage of the various groups are given below, and the accommodation required is summarized in para. 15, below.

6. **Group 1.—Locomotives and rolling stock.**—Requirements may be taken to vary directly with the size of the force and the length of the rail communications. Provision for storage of the group, including spare parts, will be made at railway workshops and running sheds and not in the stores depot.

7. **Group 2.—Permanent way stores.**—The total quantity will depend on :—

i. the amount of new line to be constructed ;
ii. the extensions required to existing facilities for depots, railheads, etc., which will vary to a certain extent with the size of the force ;
iii. maintenance, depending on the length of line to be operated.

The proportion of this total requiring storage in the depot depends on a variety of factors, such as the rate of construction, the distance from the source of supply and the shipping situation.

The type plan shows storage for 100 miles of track complete, with 500 turn-outs. The group also includes 80 tons of plate-laying tools, etc.

8. **Group 3.—Bridging.**—Heavy material must be stacked within crane radius, with spans parallel to the siding, culverts, cubes, etc., being stacked in the centre of the bays.

9. **Group 4.—Water supply.**—It is desirable to have at least 50 per cent. of these stores under cover, to protect pumps, special fittings, etc.

10. **Group 5.—Workshop and running shed.**—This is not included in railway stores depot.

11. **Group 8.—General engineering.**—This may be taken as requiring 25 ft. super per ton to cover stacking and gangways. This can be reduced for the metal store to 15 ft. super per ton.

12. **Group 9.—Plant.**—This section includes a number of cranes, pile drivers and other plant on railway wheels, for which about 1,000 ft. run storage siding will be required. A siding with an end loading dock is also necessary for digger and similar plant on caterpillar tracks. About 800 tons of Decauville track and stock are included in this group.

13. **Group 12.—Explosives and demolition stores.**—These will be required by railway units, who will obtain them through the usual channels.

14. **Group 13.—Miscellaneous stores.**—Locomotive coal is included in this group, but no provision has been made for storage in the stores depot, as it should not be necessary to

stack coal at places other than locomotive depots or engine changing stations. (*See* Military Engineering, Vol. VIII, 1929, Sec. **82**, **3**.)

15. Storage accommodation :—

TABLE I.—SUMMARY OF STORAGE ACCOMMODATION REQUIRED IN A RAILWAY STORES DEPOT

	Group.	Approximate tonnage.	Stacking Area. f.s.	Covered storage. f.s.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)
2	Permanent way (*a*) Materials (*b*) Tools ...	33,000 80	— 555,000	2,000 B 2,000 A	— —
3	Bridging stores	3,500	160,000	—	—
4	Water supply	470	12,000	5,000 A	—
6	Signalling and operating.	— 100	— 2,500	1,000 A 1,500 B	— —
7	Survey ...	40	1,500	1,500 A	—
8	General engineering	100	2,500	2,500 A	—
9	Plant	1,800	80,000 f.s. and 1,000 f.r. siding.*	5,000 A	* For plant on railway mountings.
10	Metals and ironmongery	— 450	— 7,000	2,000 A 5,000 B	— —
11	Timber ...	1,200	40,000	15,000 B *	* An open shed with roof cover only will suffice.
13	Misc. Stores ...	600	15,000	10,000 A	—

Total covered storage required ... 29,000 f.s. priority A.
23,500 f.s. priority B.

NOTE.—The stacking areas (Col. 4) include the covered areas in Col. 5.

Covered Storage.—Priority A is necessary.
Priority B is desirable if stores are not to deteriorate.

16. **Additional buildings** required are :—

Office accommodation for 7 officers and 15 clerks, to include a small drawing office, total area approximately 2,250 f.s. This should be in a central

position, with road access, and of standard 28-ft. span (Pl. **15**).

ii. A small workshop and sawmill 100 ft. by 36 ft., which could suitably be sited in the bay containing plant, adjacent to the timber.

iii. Latrines and ablution places, as convenient in the depot.

iv. A personnel camp for 7 officers and 261 O.Rs.

v. A civilian labour camp for 100 will also probably be required.

The personnel camps should be outside the depot, but within reasonable walking distance of it.

17. **Type of construction.**—Store shedding will be of standard design, normally 72 ft. wide, built up of two standard 36-ft. spans (Pl. **23**). The length of the sheds will be as required, but should not exceed a maximum of 400 ft. for any one shed. Where required covered platforms to the sheds will be provided as indicated in Sec. **117**.

18. **Locomotive steam cranes,** for handling stores as required will be provided by the transportation directorate.

19. **Water supply** will be required for :—

i. drinking and general purposes ;

ii. shunting engines and steam cranes (6-in. water column).

In addition a 4-in. fire main for the protection of timber and sleeper stacks is desirable.

PART V.—PRODUCTIVE INSTALLATIONS

INTRODUCTION

As a campaign develops it may become necessary for economic reasons, chief amongst which will be the necessity of reducing the tonnage of stores shipped to an overseas theatre of war, to develop local resources to their utmost extent, and to start productive installations of various kinds. Part V gives details of the more important installations which may be required under varying conditions, and of the principles underlying each, so that they may be laid out and constructed on sound lines and with due regard to the modifications of civil practice imposed by war conditions.

Generally the specifications for plant and the details of the work will be those of civil practice, since special provision for war needs may be slow and uneconomic, but the performance required, the lay-out and the broad lines of the design must be based on military requirements and local considerations.

To achieve the best results there should be consultation between the civil specialist consulting engineer, who will know the possibilities and plant available from existing production machinery, and the engineer officer, who will obtain from the administrative staff and other officers concerned the general requirements and any essential considerations from the point of view of defence, etc.

In this consultation all relevant local factors such as site, accessibility, climate, water supply, transport and labour must be gone into, and the importance of designing the lay-out so as to minimize the effects of air attack must be considered.

Such joint deliberation may often be impracticable, and it is essential therefore that the engineer officer who is given the responsibility of designing any such productive installation shall be able to form a sound decision on his own.

Part V indicates therefore for those installations which are likely to be required, the principles governing their institution, the performance which may reasonably be expected, the floor spaces required and the modifications which war conditions may impose on normal peace designs.

An exhaustive treatment of the various subjects cannot be included in this manual, and for further information reference must be made to the following military text-books :—

Text Book of Mechanical Engineering ;

Text Book of Electrical Engineering ;

and to the various publications dealing with these specific subjects.

CHAPTER XXVI

TIMBER PRODUCTION

135. Forest exploitation

1. The demand for timber by an army in the field tends rapidly to assume huge proportions, a process accelerated by any stabilization of the fighting line.

The quantities procurable from home (especially in view of shipping difficulties) and by local purchase may prove inadequate; and the exploitation of forests in the theatre of war may become a matter of necessity.

2. The forest resources of the theatre of war must be surveyed as a whole, especially with regard to facility of transport, as it will be usually found that forests are situated in sparsely inhabited districts with correspondingly poor communications.

Whether state owned or private, forests will be in charge of a forestry service of a kind, and in all but the most uncivilized countries a regular programme of exploitation will have been established. This will be on the basis of a limited output and replanting to safeguard future interests.

Such a rate of exploitation would be of little value in war, where the requirements of timber demand rapid production.

It is imperative therefore to establish the closest co-operation with the local forestry service from the start with a view to obtaining this.

3. Forests can be classified as under :—

i.	Coniferous ...	... Pine and fir.
ii.	Hard wood ...	... Beech, oak, elm, ash, etc.
iii.	Mixed ...	... Mixed coniferous and hard-woods.
iv	Thickets ...	... Smaller types of trees.

Probably in none of these will wholesale or indiscriminate felling be permissible, although, with artificially planted coniferous forests, clear felling may be possible on condition of replanting.

The list below gives an indication of the uses of various timbers in war.

Ash	Wheels, tool handles, etc.
Very hard woods, such as hornbeam	Wedges, scotches, etc.
All soft woods, oak and beech	Railway sleepers.
Hardwoods, and oak ...	Road planks and slabs.
Soft woods	Sawn timbers for hutting and defence purposes.
Pine and larch	Telegraph poles.
Thickets and undergrowth generally	Pickets and brushwood—selected for fascines.

4. Standardization is an essential condition of production on a large scale, and the requirements of the army should consequently be forecasted on the basis of a three or preferably six-month indent. Detailed sawing instructions can then be circulated after expert consideration of the estimated requirements, in order that every log shall be utilized in the manner most advantageous to the needs of the army.

Without such instructions, production is haphazard and wasteful, and, once exploitation has actively started, it is not easy to modify specifications without seriously diminishing production and causing waste.

Typical detailed sawing instructions are given in Appendix XIV.

5. In any forest selected for exploitation, the first step is to carry out a rough survey to ascertain :—

i. the approximate supplies available, measured in cubic feet ;

ii. the approximate quantities of the various supplies, measured in cubic feet ;

iii. the different species of trees and the sizes.

This survey should be carried out in conjunction with the forest service concerned.

A convenient method of doing this is as follows :—

One or more typical portions of the forest are selected, the number depending upon the total area, and the variations in growth and density.

A definite area should be paced out—say half to one acre—and the number of trees of each species contained in it ascertained. The quarter girth of each should be measured, and the height of the trunk estimated.

An alternative method is to check about 10 per cent. of the forest by selecting a typical section and running a measured traverse through any portion of the selected section, with

lines about 50 ft. long on either side of the traverse. The girths of the trees in these areas are then measured, heights estimated, and the different species noted.

The process is repeated until the whole 10 per cent. of the forest has been covered.

After reasonable allowance has been made for taper in the diameter of logs the contents should be computed from Hoppus' or other tables. Hoppus' tables give results about 20 per cent. less than the actual contents of the log. Timber merchants consider this allowance necessary to cover loss on conversion into sawn timber.

This information will give an approximate idea of the timber available and the approximate total supply can then be computed from a map of the forest.

6. Besides timber fit for the saw-mill a forest will usually contain undergrowth suitable for making into fascines, pickets, fuelwood, etc.

On the results of the survey the work can be planned, and the site of the saw-mill, and means of transport to it, decided.

In deciding the plan of exploitation the main lines of transport should be determined. If main roads exist, decauville or other track will generally be laid along them, and suitable lines for side tracks leading from them will be settled on.

7. Work is then begun on a section near a main transport line. The first gang clears the undergrowth with billhooks, axes and perhaps a few saws, and is followed by a second gang, which converts suitable material into fascines, poles, pickets, fuelwood, etc.

After a little experience is gained, it should be possible to put this gang on task work.

When these parties are sufficiently advanced a third gang is started on tree felling. Skilled civilian labour, when available, will generally be found to be far more efficient in forestry work, felling trees, etc., than men unaccustomed to the work.

The felling gang should be equipped with felling axes, hand cross-cut saws, wedges and sledge hammers, and cant hooks.

The logs are cut to the required lengths, and the tree heads converted into poles, fuelwood, etc.

8. **Felling.**—Properly felled trees should leave little of the stump above ground. Continental practice limits this to a few inches, but axe-men from the Dominions often leave a stump 2 ft. high. The former is slower, and necessitates sawing the stump.

Unless skilled men are available for tree felling the work must be carefully supervised.

Methods of felling are :—

i. by chopping the tree on opposite sides with an axe, the the cut on the side on which the tree is required to fall being the lower, or

ii. by making two cuts in the same manner with a two-handled saw, wedges being driven behind the saw to prevent it binding.

Crooked trees should preferably be felled to fall on their sides, otherwise they are liable to split.

The necessity for keeping felling tools properly sharp must always be kept in mind, and it is essential to detail at least one man in every camp solely for this duty.

After felling the trees should be cross-cut into the lengths required by the saw-mill. If there is a possibility of heavy timbers being required for bridging, etc., suitable logs should be set aside.

Trees felled when the sap is rising are very liable to decay.

The proper time to fell is when the sap is down, *i.e.* in winter.

This is frequently impossible, and in such cases it is advantageous to leave the head on the log as long as possible, as the leaves will draw some of the sap out of the wood.

9. **Transport to the saw-mill.**—Logs which have been cross-cut should be despatched to the saw-mill. They do not improve if left lying on the ground, and it is important always to have a very large supply ready at the mill. Woods and forests often become very difficult for transport in the wet season, and it is most important to get all supplies out (including fuelwood) beforehand.

All supplies produced should be removed to railheads, main roads, etc., and piled there. Wheeled transport or sledges (Pl. **89**) can generally be used for moving logs in the forest, but, owing to the frequent soft ground and bad tracks, much time is lost: and, unless the exploitation is small or of a very temporary nature, it is usually advisable to lay a decauville track on a corduroy or fascine foundation over the soft spots, with branches in various directions. Time spent in grading is quickly repaid.

The route of the track should be notified to gangers, who can then arrange for logs to be brought near the track, and for fascines, etc., to be left near the soft spots.

Petrol tractors can be used with advantage for hauling logs over the track.

In very broken country aerial ropeways can be made use of where the scope of operations justifies it; and in high forest it will frequently be necessary to construct slides or shutes to get the logs from the high ground to the lower level.

Ropeways are quickly erected, carry large quantities, and

employ few men. The temporary ones are not suitable for heavy loads, but are particularly useful for sawn timber, fascines, etc., and can be arranged to discharge at an elevated point to facilitate rapid loading of vehicles (Chapter XXXIV).

10. A satisfactory method of exploiting a forest is probably one in which a main rail line, or lines, follows near a contour line through it, having possibly a few rail branches from it. Branch trails are then cut to the track, and the logs, etc., "snigged" to these by horses or mules. Rising gradients are not satisfactory for loaded trucks, unless the grade is very slight. At the forest loading points skids should be erected sloping up to the floors of the trucks to prevent derailing while loading is taking place.

Transporting logs out of a forest is very slow work, unless plenty of hard roads are available or light tracks are laid.

Logging cars and trucks suitable for use on light railways are illustrated on Pls. **89** and **90**.

11. As soon as the site of the mill has been settled it is desirable to commence carting logs there; as, unless the transport arrangements are very efficient, great difficulty will be found in keeping the mill supplied, especially if once working it is called upon to work double shifts.

It may sometimes be an advantage to have the mill in the forest, and the sawn lumber and brushwood dumps near railheads or roadways some distance away.

136. Saw-mills

1. **Siting.**—The site of the saw-mill is governed primarily by transport considerations, but, if the mill is steam driven, water must be available; this may present some difficulty in high forests.

The trees round the saw-mill and camp should not be cut down, as they help to give concealment from the air. The exhaust steam is easily seen, and it may be advisable to "break it up" as it leaves the stack, should there be any risk of its attracting attention.

Generally speaking, as the round log is more awkward to transport than sawn timber the carry from the forest to the mill should be kept to a minimum; at the same time every effort should be made to utilize any favourable conformation of the ground to avoid lifting timber. Thus on a slope it may be possible to deliver logs to a dump above the level of the breaking down bench, to which they may be skidded down as required.

2. Accumulations of timber awaiting despatch should be stacked under the various specifications. Scantlings should

be laid on level ground and the sawn timber piled on them with laths between each layer to permit free circulation of air.

It is essential therefore that the site should have ample space for this purpose, with proper roadways in and out to avoid congestion, and for dumps of logs, pickets, etc.

It is desirable to have more than one dump to reduce fire risks.

After conversion, the products of the mill may be cleared by road, rail, rope or waterway, but where possible the most economical means, *e.g.* rail or water should be sought.

Whatever the local conditions, the problem of transport both to and from the mill must be solved in relation to the capacity of the mill, and with the utmost economy of labour.

3. As a guide to transport requirements the weights of the more common timbers, etc., are given in the table below.

TABLE J.—WEIGHTS OF COMMON TIMBERS

Timber.	Weight in lb. per cubic ft.		Remarks.
	Green.	Seasoned.	
(1)	(2)	(3)	(4)
Ash	54–66	43–53	—
Beech	54–66	43–53	—
Birch	56–61	45–49	—
Cedar	44–59	35–47	—
Chestnut	44–51	35–41	—
Elm	43–46	34–37	—
Fir, spruce	36–40	29–32	—
„ Baltic	43–45	34–36	—
Larch	40–47	32–38	—
Oak	61–72	49–58	—
Poplar	29–32	23–26	—
Teak	51–65	41–52	—
Hornbeam	60	48	—
Poles, 13-ft. Stout	270 each	—	These are average
Poles, 13-ft. Medium	100 „	—	weights only, and
„ 10-ft. „	75 „	—	may vary by as
Pickets, 6-ft. and under	9–3 „	—	much as 20 per
Poles, telegraph, 15-ft.	112 „	—	cent. either way.
„ „ 20-ft.	170 „	—	If timber is sea-
„ „ 24-ft.	240 „	—	soned 10 per cent.
„ „ 30-ft.	370 „	—	may be deducted.
„ „ 34-ft.	420 „	—	
„ „ 40-ft.	660 „	—	
„ „ 50-ft.	850 „	—	
„ „ 60-ft.	1,380 „	—	
Hurdles, 1 ft. 9 in. × 3 ft.	32 „	—	Only made with
„ 3 ft. × 6 ft. ...	56 „	—	"green" wood.
„ 4 ft. × 6 ft. ...	75 „	—	„
Fascines, 10 ft. × 10 in. dia.	90 „	—	„
Fascines, 18 ft. × 9 in. diam.	140 „	—	„

4. **Records.**—Statistical records in the form of daily reports should be maintained of the following :—

i. Trees felled or available for felling within range of the mill.
ii. The intake of logs, pickets, etc., from the forest to the dump.
iii. Timber sawn by each shift in the mill, in the various specifications.
iv. Stacks of timber sawn to specification ready in the dump.
v. Despatches of sawn timber, poles, pickets, etc.
vi. Personnel employed.
vii. Receipts and issues of tools to forest parties. (These should be checked in daily.)

Specimen headings for daily reports are given in Appendix XII.

5. It is impossible to lay down any standards for the output of timber from forestry saw-mills, or to effect any fair comparison between different areas, owing to the wide variation in conditions, especially of transport.

The following figures, which cover felling and sawing, are given to illustrate experience in France in the Great War.

Type of Forest.	Output of timber per 6-day week. Round and sawn. Tons.	No. of men employed (inclusive of all employees and transport personnel).	Tons per man per day.
(1)	(2)	(3)	(4)
Scotch fir ...	533	174	0·5
Hardwood and pine	1,364	464	0·5
Pine	611	145	0·7

6. **Mill design and plant.**—Sometimes a saw-mill may be available which is or can be made suitable for the requirements, in which case it is usually advisable to use it in preference to erecting one.

The principal, or breaking down, saw for cutting the logs may be one of the following types :—

i. Circular saw, with teeth cut on the edge or inserted.
ii. Vertical bandsaw.
iii. Frame saw.
iv. Horizontal saw.

Bandsaws require highly skilled sawyers to set them, adjust the tension, braze them, etc., and are not suitable.

Frame saws have a number of saw blades set in frames propelled vertically, and are too cumbersome to be portable.

Horizontal saws are slow.

Circular saws are the most suitable for general purposes; those with inserted teeth cut more rapidly, but the cut is nearly ¼ in. wide, causing waste, and requiring additional power to drive them.

When an "inserted tooth" saw is used, it is sometimes found advisable to have a small jet of water playing on the saw under the arbor, as it helps the saw.

For a semi-permanent mill the most suitable arrangement is a circular saw with a log carriage having mechanical means for holding the log in place and for moving it backwards and forwards across the carriage, so that, as a plank is sawn off, the log can be moved forward by a lever for the next cut.

The carriage should be moved towards and away from the saw by power, the return movement being more rapid than the advance and controlled by a lever.

Suitable mills of this type are the portable (Scotch) mill and the semi-portable (Canadian) mill.

137. Portable Scotch mill

1. For the conversion of timber up to 2 ft. diameter the (Scotch) type of mill shown on Pl. **91** is in regular commercial use. Twin rack benches are employed with saws of 4 ft. 6 in. and 3 ft. 6 in. diameter, driven by a 30 h.p. portable steam engine.

The timber is placed on a timber-framed travelling table running on rollers and fed mechanically or by hand to the breaking-down saw by means of a pinion driving a rack bolted on the underside of the table: some mechanical means of holding the log in place will avoid waste of time in securing it, and will reduce any danger of twisting while it is being sawn. The second bench is employed for running off scantling; a cross-cut saw for cutting to length can be driven off the same engine.

2. Where the mill can be laid down with a fair chance of working for three months the introduction of a sunk counter-shaft as shown on Pl. **91** is fully justified.

A more easily transportable type is in fairly general use, having both saws on one spindle driven direct from the engine flywheel. Such a mill can be picked up in a few hours but has these disadvantages:—

- i. Saws can only be stopped by stopping the engine.
- ii. When one saw is stopped the other must be idle, and, when both saws are in a heavy cut, one sawyer may have to wait on the other.
- iii. The belting being above the benches at the rear of the saw there is less room for taking off timber.

3. In any case the whole mill can be laid down on sleeper foundations, and the countershaft frame loaded with stones or earth. The use of a rope drive on semi-portable mills has proved advantageous, owing to a tendency with temporary foundations for belt trouble to arise from the engine moving. A good foundation is necessary for the saw-bench.

4. Under normal conditions the staff of such a mill would number 8 (1 engineman, 2 sawyers and their assistants, 1 saw sharpener, and 2 men taking away and stacking timber). The output of sleepers and planking, such as road slabs, would average about 2,000 cu. ft. a week.

5. While it is more economical in machinery and personnel to have one 30 h.p. engine per mill, the use of single benches and smaller engines may prove economical where the timber is light, as in most conifer forests, and in scattered parcels. Such benches require less accuracy in setting out and can be worked by less experienced personnel. The net weight of a self-acting bench with 36-in. saw only amounts to 24 cwt., excluding the carriage and rails.

In any case, with this type of mill it is useful to have a small circular saw bench, with possibly a petrol engine, to do any resaw work such as cutting small specifications from planks.

138. Semi-portable (Canadian) mill

1. Pl. **92** shows the lay-out of a semi-portable mill used by the Canadian forestry corps in France.

The mill unit comprises :—

i. 1 circular saw, 48 to 60-in., for breaking-down with log carriage driven by rope or chain feed. In addition to the forward and return movement of the log carriage some mechanical means should be provided for holding the log in place and moving it across the carriage for the next cut. Wedge shaped blocks hinged on the end of log skids considerably facilitate turning the log when in the carriage. The wedges when not in use fall to the side of the skid (Pl. 93).

ii. 1 pendulum saw, 20 to 24-in., for cross cutting to length.

iii. 1 edger for running off planking to width. This has two circular saws mounted on one spindle, the distance between them being adjustable to the required width of plank : both edges are therefore cut at one operation.

Alternatively two 24-in. circular saws for scantling and small work on off-cuts, etc., may be provided. This is generally the more useful.

iv. A saw-doctor's shop with sharpening and gulleting machines, grinder, etc., a store, and an office.

The whole of the mill is driven by a steam engine (80 h.p.) through countershafting and belting; steam is raised in a pair of semi-portable boilers with fire-boxes suitable for burning wood refuse. In addition the mill is equipped with a separate lighting plant (10 kw. dynamo).

2. The lay-out is designed to secure a natural sequence of operations with the least labour in moving material. On arrival, the timber wagons are hauled by a winch to the level of the top of the feeding skids, from which the logs are transferred as required to the travelling carriage feeding the circular saw. Here the logs are broken down to planks of the required thickness, which pass on chain driven rolls to the pendulum saw for cross cutting or squaring the ends. The sawn timber can now be skidded sideways to the edging bench or, if no further work is required, passed on rolls or skids direct to wagons for forwarding.

Certain advantages are derived from placing the machinery at high level, say 8 ft. above ground. The whole sequence of operations can then take place in a downward direction, and the output from the saws can be skidded clear quickly, while, if the platform be extended alongside the loading lines at least 3 ft. above rail level, the loading of wagons for despatch will be greatly facilitated. Overhead shafting can then be avoided, and the roof construction simplified, while there is no risk of timber fouling belts. On the other hand extra time and material are involved in the initial construction.

3. With skilled men and the simplest form of construction it should be possible to erect such a plant within a week; 15 men should be sufficient to operate the mill, exclusive of those employed on bringing logs to the mill and conveying produce away.

4. 4. The output would average about 30,000 f.b.m. (feet board measure) a day.

5. Live rollers or rollers erected at the level of the bench and about 2 ft. wide to convey sawn material away from the saw considerably facilitate the work and reduce labour. Generally they convey the timber to the end of the mill building, where it is dropped on to decauville trucks and wheeled to the stacks in the dump.

The skids on which the logs lie ready for the breaking down saws should be long, to permit of a good number being always available for the sawyer.

When large specifications and sleepers are being cut, logs are consumed very rapidly.

For sawing split poles the work may be speeded up by constructing a V-shaped wooden trough in front of a resaw bench, so that the round poles may be kept in position.

6. Saw-mills should be lit by electricity whenever possible, for preference the power plant should be a small petrol engine, so that in the event of a breakdown of the main engines repairs can, if necessary, be carried out at night.

7. It is very necessary that axes, billhooks etc., shall be kept sharp, and men must be supplied with hones, and grindstones provided in camps.

A tool shed with a man in charge is essential to prevent excessive loss by forest parties.

139. Dump lay-out

1. Supplies are frequently required rapidly, and it is therefore advisable to lay out the dumps carefully with good roads planned for in and out traffic where alongside a road; and, wherever possible, keeping the bottoms of the stacks of timber as near the level of the floor of the vehicles as possible, to avoid having to lift the timber, which delays loading.

2. If cranes can be made available the timber should be piled in sling loads with skids in between to permit of the chain hook being passed round.

When required the slings of timber can be lifted off and loaded into the vehicle very rapidly.

3. Fuel wood should, where possible, be kept in a separate dump from sawn timber and pickets, fascines, etc. It should be properly stacked, so that the quantity can be readily estimated, and issues checked.

In winter months demands may be very heavy, and supplies must be brought to railheads and roadsides beforehand.

4. Charcoal can be manufactured, but requires experienced men, and is liable to deteriorate very rapidly unless protected from damp.

5. The question of having more than one dump with a saw-mill should be considered, as the stack may easily be destroyed by fire, and concealment from the air is difficult.

140. Machinery and stores

Appendix XIII gives a list of the machinery and stores which would probably be required for the exploitation of a forest and a saw-mill, where the timber available was sufficient to supply the saw-mill for at least six months.

The tools and spares required by the forest parties depend to a considerable extent on the nature of the forest and the rate at which the work is to be carried out.

The figures given are based on the assumption that the saw-mill is to be kept supplied with logs for about ten hours each day and that all suitable brushwood and tree tops are to be made into fascines, pickets, fuelwood, etc.

The list includes a reserve of tools to replace loss and breakage.

CHAPTER XXVII

MANUFACTURE OF BRICKS, LIME AND CONCRETE PRODUCTS

141. Burnt bricks

1. In many theatres of war it may become necessary to supplement steel or wood and corrugated iron huts, whether of standard pattern or of local construction, by construction in other materials. Of these brick, whether sun-dried or burnt, is likely to be by far the most common, as suitable brick earths are to be found in most parts of the world.

2. Where there are existing brick-yards the procedure is simple and will merely consist in taking the necessary steps to augment production by whatever means is necessary. In certain cases this may necessitate the taking over of the existing installation, and the introduction of additional labour and brick-making machinery, and generally increasing the scope of operations. In others it may be merely a matter of placing contracts for the number required.

3. Where there are no brick-yards in existence, it will usually be necessary to start in the most primitive fashion, and gradually to extend and improve the various operations by the installation of mechanical plant.

4. **Brick earths** :—

i. **Clay** (alumina) is the basic ingredient of all brick-earths and supplies the plasticity required for moulding.

When pure it is liable to shrink, crack and warp during burning.

ii. **Sand** (silica) is therefore added to reduce this tendency and to provide free silica, which, on melting, acts as a binding agent.

iii. **Chalk** (calcium carbonate) **or oxide of iron** are also essential ingredients, since they act as fluxes, reducing the temperature at which the melting of the silica occurs.

The following table gives a classification of the various natural brick earths :—

TABLE K.—CLASSIFICATION OF NATURAL BRICK EARTHS

Brick earth.	Constituents.	Remarks.
(1)	(2)	(3)
Plastic, Strong, Pure } clays	Practically pure clay, with only a small proportion of sand, chalk, etc.	Highly plastic. Usually free from stones. Tend to warp and shrink during burning.
Mild, Sandy, loams } clays	High proportion of sand and gravel. Low proportion of chalk and impurities.	When of medium plasticity, make good brick earths. Usually require addition of chalk.
Calcareous clays Marls	Natural mixture of clay and chalk, usually low in sand content.	The best earths for bricks, and usually require less treatment than the other classes.
Rock clays i. Shales	Variable. Frequently high carbonaceous content, and often high percentage of iron.	Normally found near coal measures, and liable to contain obnoxious metallic salts. Require power plant for digging, washing and moulding.
ii. Fire clays	Either 90 per cent. silica or approx. 30–40 per cent. alumina and 60–70 per cent. silica.	Highly refractory, and used largely for furnace backing and sanitary ware.

It will be seen from the above table that few brick-earths can be used in their natural state for the manufacture of bricks, and the proportions have to be adjusted by the addition of the constituents lacking, which in most cases are chalk and sand.

5. It is impossible to lay down an analysis for an ideal brick earth, but the following proportions should always give good results :—

Alumina, 20–35 per cent.
Silica, 40–60 per cent.
Calcium carbonate } 20–25 per cent.
Magnesium carbonate }
Oxide of iron, etc., not exceeding 10 per cent.

Too much reliance should not be placed on a chemical analysis, and the most satisfactory method of testing the suitability of a brick earth is by means of a practical test.

6. **Testing of brick-earths.**—At least ½ cu. yd. of the clay (equivalent to an output of 150 bricks) should be prepared and burnt as in actual manufacture. In the event of the resulting bricks proving unsatisfactory a series of mixtures (malms) of varying constituencies should be tried, the "green" bricks of each type being given distinguishing marks. If different methods of moulding and burning are employed on samples of each type, not only the best malm, but also the most satisfactory method of manufacture, will be simultaneously discovered.

7. The progressive stages in the manufacture of a brick are as follows :—

(Full details can be obtained from any of the recognized civil textbooks.)

i. **Removal of the top soil** or vegetable loam from the brick earth.

ii. **Digging the brick-earth**—either by hand or mechanical digger ; or, with hard shales, by quarrying.

iii. **Weathering the clay**—*i.e.* breaking it up to make it more plastic. This can be done by natural means by exposing the dug clay in heaps to the action of the weather (frost and rain) during the winter, or by mechanical means, *e.g.* grinding. (*See* sub-para. viii, below.)

iv. **Cleaning**—*i.e.* removal of stones, by hand if in small quantities, by washing in mechanical cleaners if in large.

v. **Washing.**—If water is available at the clay pit, it can be mixed with the clay to form a slurry. This has the advantage of :—

(*a*) getting rid of the stones ;
(*b*) giving simple means of transport to the works, particularly if a gravity flow can be given ;
(*c*) facilitating admixture with chalk, where that has to be added.

The slurry, however, takes a long time to dry out, and requires a lot of space in which to do so, or additional expenditure on drying plant.

A wash mill usually consists of a circular tank some 14 ft. in diameter and 4 to 6 ft. deep, in the centre of which is a pillar, with its lower part of brick and upper of metal. This pillar acts as a pivot, on which is hung a frame containing a number of suspended harrows or washing gates.

The frame is rotated 9 to 10 times a minute by horse or mechanical power.

It requires about 7 h.p. to turn it, and will treat from 20 to 40 cu. yds. of material a day, the higher figure being reached with a fine marl or clay.

vi. **Settling.**—The slurry is run along wooden troughs into a series of reservoirs (backs) about 50 ft. square by 4 to 10 ft. deep, care being taken to distribute it evenly over the back. The malm settles down in the backs, and the surplus water is run off.

As soon as it is stiff enough for men to walk on a layer of sandy loam is spread over the surface to prevent it getting hard and leathery.

When the resulting bricks are clamp burnt, a layer of combustible material such as cinder dust, breeze, etc., is also spread over the surface to a thickness of 3–4 in. per ft. depth of the back.

vii. **Removal to the pug mill.**—The malm is dug out on a vertical face to preserve the correct proportions of the constituents, and is transported in tip trucks by light railway to the pug mill.

viii. **Grinding.**—Where complete natural weathering of the clay cannot be resorted to, mechanical grinding takes its place in a mill situated above the pug mill.

The clay, having been freed from stones, is conveyed by tip truck on a tramway, or by other means, to the grinding shed, where it is emptied out on the floor, and any other necessary ingredients added to it before it is shovelled into the grinding pan.

This is usually a circular pit, in which a pair of heavy steel fixed rollers revolve round a central pivot, over a slotted steel grating. A water spray is connected to the rollers, by means of which the clay is moistened to the correct consistency. About 3–5 h.p. is required per pair of rollers. From the grinding mill the clay is fed to the hopper of the pug mill.

ix. **Pugging.**—In essence pugging consists of thoroughly mixing the clay where necessary with the addition of water, until a homogeneous paste is obtained.

In its primitive form a pug mill consists of a circular tank in which work rotating arms fitted with projecting blades or knives. The arms can be rotated by animal or mechanical power.

The plastic clay then passes through an orifice in the container, and is cut or otherwise moulded into shapes. The modern type of pug mill consists of a rotating shaft to which knives acting on the archimedean principle are attached, working inside a

cylindrical metal casing, and arranged either vertically or horizontally.

The moulding machine usually forms part of the modern pug mill. Pug mills require from 2–6 h.p. to drive them, according to type.

A home-made pug mill is illustrated in Pl. **94.**

x. **Moulding.**—This can be either by hand or machine.

(*a*) **With hand moulding,** the clay must have the consistency of dough, and be stiff enough to retain the impression of the mould. It can be done in two ways—(i) slop moulding, or (ii) sand moulding.

With either process the moulder works at a table or "stool" of convenient height and size, *e.g.* 6 ft. × 3 ft. × 3 ft., fitted with a sandbox and a water tank. The mould consists of a metal lined wooden frame without top or bottom, 10 in. × 5 in. × 3 in. in dimension.

The table is sanded and the mould filled with clay, which is kneaded well into the corners, and any surplus struck off with a straight-edge.

The difference in the processes consists in the method of cleaning the mould, which is either by water or sand. Where sand is used the resulting brick is stiffer, and the mould can, therefore, be struck at once and reused. With slop moulding extra moulds are required, as the brick is too soft to stand on its own until partially dried out. With skilled labour the output should be about 1,500 bricks per table per day in the slop moulding process, and about 4,500 per day with sand moulding.

(*b*) **With machine moulding,** there are also two different processes, (i) wire cutting and (ii) pressing.

(i) Wire cutting is a slop moulding process used with plastic clays and is the simplest form of plant to employ in small installations.

It consists simply of cutting by wires the plastic clay as it is forced out through the orifice of the pug mill on to a cutting table. The orifice is fitted with a selection of dies varying in shape according to the type of brick required, and a series of cutting wires are accurately spaced at brick length on a framework, which can be worked either automatically or by hand.

The cut bricks are moved on a sliding tray to carriers or barrows, by which they are transferred to the drying sheds.

(ii) Pressing is normally done in mechanical presses, although hand pressing can be employed in the plastic process for small outputs. It is normally employed when grinding has to be resorted to, *i.e.* with hard clays and shales, where the stiff plastic process is adopted, or with ordinary clays as an alternative or addition to wire cutting, where the semi-plastic process is used. In either process the press is usually part of a combined plant, which carries out automatically the functions of mixing, pugging, moulding and pressing or cutting.

According to the type of clay, pressures from 80 to 300 tons per brick are employed in the semi-plastic process, and a series of from 2 to 4 pressures applied. With the stiff plastic process pressures seldom exceed 50 tons per brick, and this process has the advantage of eliminating any intermediate period of drying before burning. The output varies from about 500 to 1,500 bricks an hour according to the type of machine, with a consumption of $1\frac{1}{2}$ to 2 h.p.

xi. **Drying.**—This may be carried out in any one of three ways; by means of (*a*) hacks, (*b*) drying floors, or (*c*) tunnel driers.

(*a*) **Hacks.**—In this method the bricks are dried by exposure to a free current of air in shelters with slatted ends (Pl. **95**, Fig. 1). Adjustable slatted screens are fitted between the roofs to protect the bricks from driving rain without decreasing the ventilation.

The bricks are laid on edge on planks in two rows about 8 in. apart and staggered with 5–8 in. between bricks.

When partially dried the bricks are skintled or relayed in two layers set diagonally. Occasionally in unfavourable weather reskintling or piling up into four layers has to be resorted to.

In a climate such as that of the United Kingdom the process is slow, some 2 to 6 weeks, or even longer, being required, depending on the weather.

(*b*) **Drying floors.**—In this process bricks are placed either in a single layer or in stacks up to 3 ft. high on a specially constructed floor which is heated by steam, flue gases from coal or coke fires, or kiln gases.

Some 2 to 5 days is taken in this process, but it is expensive and requires careful operation.

(*c*) **Tunnel driers**—either intermittent or continuous.—In either case a tunnel has to be constructed (Pl. **95**, Fig. 2). In the intermittent

process the tunnel is filled by packing the bricks on racks or shelves.

In the continuous process, the bricks are loaded in the moulding shed on to specially constructed trucks, which run on rails through the tunnel.

The heating gases are drawn through the tunnel by means of fans, and the process takes from 1 to 5 days.

xii. **Burning.**—This may be carried out in either clamps or kilns, the choice depending on the nature of the clay and the type of brick required.

(*a*) Clamps are quicker to build and cheaper in initial cost, but the temperatures attainable are limited, and, as little control is possible during burning, the resulting products are uneven. It is only suitable when small fuel (½-in. gauge or under) is available.

A clamp consists of a series of walls 9 in. thick, projecting on either side of a central upright, or double battered wall, 6 bricks thick at the base and 3 at the top. The dimensions of a clamp can be widely varied to suit the site, but a normal section is 54 ft. wide by 10–14 ft. high.

Much smaller clamps to hold 100,000 to 200,000 bricks can be utilized where an immediate supply of burnt bricks is required.

To build a clamp the site is first cleared, levelled, drained and consolidated with rubble to a dish-shaped formation in order to give a slight batter to the outer walls.

It is then paved with a double layer of burnt bricks set close on edge, on which two further courses are laid, the bricks in the lower course being placed diagonally about 2 in. apart, and those in the upper across the clamp and close together.

Channels 9 in. square extending right across the clamp are left in these courses at 25 to 30-ft. intervals and are filled with faggots for lighting or restarting the fire.

Fuel is poured into the interstices between the bricks and spread over the surface to a depth of about 7 in., increasing to 9 in. at the edges to augment the batter.

A course of green bricks, all headers, is next laid and covered with a 4-in. layer of fuel, and then a course of green stretchers.

The central upright and the projecting walls are then built up to their full height, and the clamp

filled with green bricks. The ends, sides and top of the clamp are closed with layers of burnt bricks, and may be plastered or screened as required to reduce the draught.

Firing can be started as soon as some 15 to 20-ft. length of clamp has been built, by lighting the faggots in the first channel. As soon as this has been burning for about 24 hours the opening is blocked with bricks and plastered over.

Burning takes from 3 to 6 weeks, and the process may be semi-continuous, *i.e.* crowding, burning and unloading may be taking place simultaneously in the same clamp.

With small clamps of capacity up to 200,000 bricks, burning should not take more than 5 to 6 days.

Almost any type of fuel can be used, *e.g.* slack coal or lignite, mixed with sawdust, wood shavings, coke breeze, charcoal, etc., but the duration of burning can only be determined by experiment.

A typical clamp is illustrated in Pl. **96**.

(*b*) **Kilns.**—These are of varying types, but may be divided into two main groups :—

(i) Single or intermittent.

(ii) Semi-continuous or continuous.

The kiln differs from the clamp in that it is a permanent structure in which green bricks are loaded, burnt and then removed.

The various types are given below, and further details will be found in the appropriate commercial textbooks.

TABLE L.—TYPES OF KILN

Kiln.	Type.	Remarks.
(1)	(2)	(3)
1. Scotch kiln ...	Intermittent	Holds about 30,000 bricks—8 to 12 cwt. of fuel per 1,000 bricks.
Downdraught kiln	do.	Improvement on Scotch kiln, more economical in fuel, and produces more uniform bricks. Capacity about 30,000 bricks ; and, as it requires a chimney, it is economical to group several kilns round a common chimney.
Horizontal draught kiln	do.	Only economical in large sizes —really a prototype of the multi-chambered continuous kiln.

TABLE L.—TYPES OF KILN—*continued*

Kiln.	Type.	Remarks.
(1)	(2)	(3)
2. Improved Hoffman (Pl. 97)	Continuous	A typical multi-chamber continuous type. Fuel used is normally a mixture of coal and coke dust, either fed mechanically or by hand, and the average consumption is 2 to 4 cwt. per 1,000 bricks.
3. Tunnel kiln (Pl. 96)	do.	An elaborated form of the continuous tunnel drier. If the bricks themselves do not contain fuel, producer gas is the most satisfactory form of fuel.
4. Bull's kiln (Pl. 98)	do.	Can be fired with wood. This type is also suitable for oil-firing.

8. **Siting and lay-out of brick-works.**—A typical lay-out of a brick-works is given on Pl. **99**.

Whatever process is evolved it will be appreciated that a considerable " head " is required for the various stages, and a very great saving of intermediate handling and lifting will be effected if the lay-out can be arranged for gravity feeding throughout.

Good rail and road access to the works is necessary, and this may govern the actual site of the works themselves: but, other things being equal, they should be as close as possible to the clay pit.

A good water supply is essential, and there should be ample space for stacking at least 1,000,000 bricks without blocking up runs or tramways.

142. Sun-dried bricks

The process of manufacture of sun-dried bricks is a modification of that used for burnt bricks, and is as follows :—

The brick-earth having been selected, a large shallow pit is dug and partially filled with the clay. This is thoroughly watered and tempered by treading with the feet until it is free from lumps, homogeneous throughout, and stiff enough for moulding, chopped straw or bhoosa being added as a binding agent during the operation.

The bricks are then moulded by hand, the moulds taking up to 4 bricks each.

For rough work the moulding is done on the ground, which

should be sanded first, and care should be taken that the moulding floor is dead level and even before commencing. For better class bricks pallets are employed, and the bricks are left on them to dry.

Moulding can be either slop or sand; but sand moulding is specified normally for superior work only.

The bricks are left to dry for a period of from 3 to 8 days, and should be protected from the direct rays of the sun by light matting roofs. They should also be protected from the wind, which is liable to cause cracking.

Care should be taken in handling while drying and stacking to prevent the bricks from becoming distorted.

Bricks should not be moulded in the rainy season, and, generally speaking, the process can only be made use of in dry and warm climates.

143. Sand-lime or slag-lime bricks

The materials used as aggregate are sand, slag, destructor refuse, broken brick, tiles or quarry waste.

The aggregate, ground up finely, is intimately mixed with carefully hydrated lime, and moulded at a pressure of 80 tons per brick.

The ratio by weight of dry hydrated lime to the total weight of dry lime and dry sand should be between $7\frac{1}{2}$ per cent. and 10 per cent.

The bricks are then placed in a steam chamber for 5 or 6 hours, high pressure steam being used for sand, etc., and low pressure for slag.

Sand-lime bricks are ready for use the day after steaming. Slag-lime bricks require to mature in the open air for 2 to 3 weeks before use.

They can be employed in a similar way to burnt bricks and for every purpose for which burnt bricks are used, and are of value when lime is available but brick earths are unobtainable.

144. Lime manufacture

1. There are many demands for lime on active service for both buildings and sanitary purposes; and, as its manufacture is quick and easy, it would be produced locally wherever possible, to save the cost and difficulty of transport from a distance.

The term lime is loosely applied to three substances :—

i. Limestone and chalk—calcium carbonate, $CaCO_3$.
ii. Quicklime—CaO.
iii. Slaked lime—hydrate of lime, $Ca(OH)_2$.

The chemical processes in the burning and setting of lime are as follows :—

Limestone is burnt to form quicklime.

$CaCO_3$ with the addition of external heat $= CaO + CO_2$.

Quicklime is slaked by the addition of water.

$CaO + H_2O = Ca(OH)_2$ with the evolution of heat.

Setting is due to the combination of CO_2 in the atmosphere with the slaked lime and the giving off of water.

$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$.

2. Hydraulicity is the capacity to set away from air and under water, and is conferred by the presence of clay, or in a lesser degree of magnesia, in the lime.

Limes are classified as fat, poor and hydraulic.

Fat limes are only suitable for plastering and whitewashing, etc. If they are used for mortar the joints only harden on the outer crust, weather badly and require much pointing. They should never be used therefore for work required to last for any considerable time.

Poor limes contain sand and are only used in the roughest work.

Hydraulic limes are used in general building work, moderately hydraulic for mortars in ordinary buildings and eminently hydraulic for important foundations and underwater work.

Hydraulic limes can always be distinguished from fat limes, largely by their colour, which is nearly pale buff or bluish, but principally by their setting hard all through when kept damp.

3. **Sources of lime.**—Fat limes can be burnt from any fairly pure limestone or chalk ; the softer the stone the cheaper will be the process.

Hydraulic limes are made from compact or argillaceous limestones or marls, and magnesium limestones.

They can also be made artificially (para. 7, below).

An argillaceous limestone can generally be recognized by the following :—

i. Earthy compact texture with brown weathered surface.
ii. Earthy smell when moistened.
iii. Soapy feel to the surface of the stone.
iv. Reduced effervescence with acid, and increased residue.

4. **Lime burning.**—Limestone is burnt to a red heat, which must be maintained until all the CO_2 is driven off. Sometimes this is more easily done if the stone is previously moistened.

When all the CO_2 has been given off, the red glow turns white, and burning should be stopped.

If heated too fast, the stone becomes slagged and useless ; if overburnt, it is difficult to slake thoroughly, and therefore dangerous ; and, if it is underburnt, portions are inert.

5. Burning takes place in kilns, of which there are two main types—continuous and intermittent.

The fuel used can be coal, coke, charcoal or wood.

Pl. **100** illustrates various types of kiln.

The tunnel kiln (Fig. 1) is normally used as a continuous kiln and is loaded with alternate layers of stone and fuel. As burning proceeds the burnt lime is raked out below and fresh layers are added on the top.

It can, however, also be worked as an intermittent kiln.

The flare kiln (Fig. 2) is an intermittent kiln, and consists of a rough arch of limestone built over the grates which contain the fuel. The rest of the kiln is packed with lumps of stone.

The fires are lit and gradually built up until the whole is burnt.

In both types pure limestone should be broken into lumps of 1 to 2 cu. ft. in volume, and hydraulic limestone into lumps about $\frac{1}{4}$ of a cu. ft.

Hydraulic limestone requires a higher temperature.

The tunnel kiln requires about $\frac{1}{5}$th of the weight of the lime produced as fuel in the form of coal or coke. It is cheap and gives a continuous supply, but there is no control over burning, and the product is uneven in quality and of a poor colour, owing to the presence of ash.

The flare kiln requires $\frac{1}{3}$ of the lime produced as fuel in the form of coal, and the complete cycle takes about one week, of which 60 to 70 hours are required for burning.

It is more expensive in fuel, but a more uniform lime of good colour is produced.

6. Another type of kiln is illustrated in Fig. 3, which can be used either for continuous or intermittent burning.

With this pattern the stone should be broken to a 2-in. gauge.

i. For continuous burning the kiln should be loaded in alternate layers of 3 in. of limestone and $\frac{1}{4}$ in. of coal dust. (Wood must not be used.)

ii. For intermittent burning, a $4\frac{1}{2}$-ft. foundation of wood is laid with alternate 2-ft. layers of stone and wood.

The top should be covered with mud, plastered over and with a 2-ft. diameter hole in the centre.

In method (i) 10 cu. ft. of coal dust are required for 100 cu. ft. of stone, and for economy the burning should proceed continuously, the kiln not being allowed to become cold. The burnt material is drawn out daily and replaced by fresh material and coal dust at the top.

When the burnt material is taken out it is hand picked: over-burnt lumps are discarded, and the unburnt ones reloaded in the kiln.

The remaining material is slaked or ground fine in a mill.

A suitable type of mill is illustrated in Fig. 4 of Pl. **100.**

Before use lime must be passed through a $\frac{1}{8}$-in. mesh screen.

100 cu. ft. of limestone should produce 81 cu. ft. of burnt material, and 100 cu. ft. of burnt material 82 cu. ft. of ground lime.

The ground lime should be placed in containers or sacks, and removed to store.

7. To produce an artificial hydraulic lime, an intimate mixture of fat lime and clay should be burnt, the proportion of clay added being that which gives a mixture similar to that of a good natural hydraulic limestone.

The actual proportion of clay to lime can only be determined by experiment, but one part of clay intimately mixed with $5\frac{1}{2}$ parts of ordinary slaked lime in paste has given good results.

The paste is made up into balls, thoroughly dried and then burnt in a kiln.

After burning such lime should be ground dry in the mill and passed through a sieve with 150 meshes to the sq. in.

It should then be kept dry under cover until required.

145. Concrete products manufacture

1. Although the demand for concrete products is not likely to be extensive, except perhaps in the case of a war of some duration, in certain places such as the permanent base and fixed points on the line of communication there may be a considerable field for their use.

The products most likely to be required are :—

i. Road slabs.
ii. Floor and paving slabs.
iii. Wall blocks.
iv. Fencing posts.
v. Kerbing.
vi. Poles for lighting and telephone lines.
vii. Reinforced concrete piles.

The demand for any one of these will depend on the availability of alternative sources of supply ; but in any theatre of war with few or no natural resources in timber, and remote from a source of supply, concrete products may be called on to supplement the supply.

An essential to any manufacture of concrete products is that there must be a suitable supply of aggregate—stone and sand or gravel—within reasonable distance.

Under such conditions it will probably prove more economical to manufacture even such items as poles and

fencing posts locally than to bring the necessary timber from a distance overseas.

2. **Siting.**—Owing to the bulk of the raw materials required the factory should be sited on the source of supply of the aggregate, *e.g.* quarry or gravel pit, or as near to it as possible, and it should have rail communication for the transport both of cement and sand and of the finished products to the engineer stores depot.

Road access is only necessary where rail communication cannot be provided, or is likely to prove insufficient.

For economic working it is necessary to reduce to a minimum the man-handling of materials or of products in the various stages of manufacture: and this calls for the careful selection of a suitable site by making full use of any natural fall in the ground. If the factory is sited near a quarry towards the top of a steep hill slope this should not be difficult.

Where, however, the slope below the quarry is inadequate for a complete gravity process mechanical hoisting will have to be installed, preferably after a preliminary crushing process.

In the case of a gravel pit in waterlogged ground the aggregate is best obtained by means of pumping, the water being used both as a vehicle to transport the stone to the required height above the screening plant and also as a washing agent.

In any case the handling of the concrete itself should be by mechanical means, wherever possible.

A typical arrangement is illustrated diagrammatically on Pl. **101**, Figs. 2 and 3.

3. **Lay-out.**—The actual lay-out of the factory will be governed by the site and by the type of product to be manufactured, but the same general principles will apply in every case.

The main essential is to have a regular sequence of operations through the factory.

A typical lay-out will therefore start with the raw materials at one end followed in sequence through the works by the mixers, machine or moulding area, finishing department, curing area and loading dock.

This is indicated in Pl. **101**, Fig. 1.

In practically every case stone crushers will be required to break up the aggregate to the required dimensions, and in some cases washing arrangements will be required for both aggregate and sand.

Cement must be stored in a weather-proof building, and it is desirable to have two doors to the store, so that a systematic turn-over of the cement can be effected.

A carpenter's shop will be required for the manufacture and repair of moulds, and space must be provided for the preparation and storage of reinforcement steel.

If a large output of reinforced concrete products is anticipated it will be economical to instal one or more bar bending and shearing machines.

If the goods manufactured do not need finishing the space set aside for the masons may be used for moulding or storage.

The actual areas required for each process will depend entirely on the process installed, the output and the type of goods manufactured, and no internal partitions should therefore be built, except for stores for raw materials.

A portion of the curing area should be under cover, but a considerable portion can be in the open.

The size of the area will depend partly on the output of the factory, but will be governed largely by the class of cement used.

With rapid hardening cement not only can moulds be released much sooner, in 8 hours instead of 24 hours, thus reducing the number held, but products can be removed to the stores depot much sooner, in 3 to 4 days instead of 14 days.

The lay-out of the moulding area depends largely on the plant installed for handling the concrete and the finished goods (para. 5, below).

If an overhead traveller is installed the benches can be much closer together than when decauville track is employed.

In any case ample working and gangway space should be allowed. Concrete benches are far the best for moulding tables. Where space permits their surfaces can be used as mould bottoms, but normally it will be necessary to remove manufactured articles to the curing area to free the moulding space for further manufacture.

In such cases the moulds must be complete with bases, and moved with the article under manufacture, unless machine production by the semi-dry process is being adopted, in which case the goods can be removed on pallets only.

4. **Construction.**—Although in many climates the manufacture of concrete products can proceed in the open, protection from the weather is very desirable, and has a marked effect on production.

Steel framed buildings covered with corrugated iron are eminently suitable, and overhead runways can be carried on brackets which can readily be fitted to the stanchions.

Where possible floors should be concreted throughout, and any light rails, etc., provided set in flush with the floor.

Cement stores must be absolutely weather-proof.

Platforms and frameworks for carrying plant, elevated bins, etc., can be made of steel, concrete or squared timber, as convenient.

5. **Plant.**—

i. The plant required will depend on the output and method of manufacture.

It will normally consist of one or more crushers fitted with rotary screens. A great saving will be effected if nothing bigger than crushed road metal is taken from the quarry, and broken up further to the required dimensions in the factory.

These vary from 1 to ⅜ in. varying by ⅛ in. according to the product manufactured; and the screens are arranged accordingly.

ii. The storage bins should be placed in sequence under the screens, and the average capacity of each should be at least sufficient for 2 days' consumption by the mixers installed.

Shutes or conveyors should be installed to take the oversize rejects back to the mouths of the crushers.

If washing has to be resorted to this should be combined with the screening, and flumes placed immediately underneath to carry away the waste water.

Types of crushers and their performances are considered in Chapter XXXV.

iii. It will frequently be impossible to arrange for a complete gravity supply from the quarry to the crushers, from the crushers to the storage bins, and from the storage bins to the mixers; in which case the most satisfactory results will probably be obtained by installing bucket or other types of conveyors from the bins and the cement store to the hoppers feeding the mixers, and by this means an easy and accurate measurement of the ingredients for the mix can be secured.

iv. If, as will usually be the case, the finer particles of the crushed stone are unsuitable in replacement of sand, sand must be obtained specially, and stored in a bin for this purpose.

This bin should also be connected to the mixer by a conveyor.

v. From the mixers the concrete will be conveyed to the moulding area. The simplest method of doing this is by a system of overhead runways carrying skips of the capacity required by the individual moulding process or machine, and arranged to deliver the concrete immediately above each machine or moulding place. These skips are best operated by hand. (Pl. **101**, Fig. 4.)

vi. There are two main processes of moulding—by machine under pressure, or by vibration.

For simple straightforward work such as flooring, paving and wall slabs, moulding in a machine, of which the "Winget" is typical, is probably the best; but with complicated products, particularly where reinforcement is used and pressure

impossible and tamping difficult, consolidation by vibration gives by far the best results.

A simple form of vibrating table is illustrated on Pl. **102.**

For many products it is not strictly necessary to press or vibrate the concrete, but tamping of some form or another is necessary. Hand tamping is very slow, and machine tamping can really only be introduced in special cases, and would only be justified for large productions of these special articles.

vii. Unless special methods are introduced moulding will usually be done in wooden moulds on a table, each mould resting on a pallet.

These pallets should be moved off the table immediately, placed on mechanical conveyors, transporters or trucks, and moved to the covered curing area, where they should remain anything from 3 to 28 days, or even longer. The time required for curing will depend not only on the class of cement used but also on the type of article manufactured. Final curing can be done in the open. The usual method of curing is by keeping the products moistened with water and covered up as necessary, but the process can be greatly accelerated by using a steam curing chamber.

A further saving in handling will result if the level of the curing floor is that of the truck floor; or if the transporter system is extended through the yard area.

6. The following is a typical plant lay-out for concrete block making :—

The coarse aggregate, sand and cement are stored in elevated hoppers at one end of the building and are fed into the mixer by gravity. The mixer—of the open drum type—is placed on a platform of such a height that the concrete can be tipped into a truck running along a track about 6 ft. above ground level. This track runs the whole length of the building, and block, slab and brick machines are spaced along each side, each machine having a small hopper above it. The truck is filled at the mixer end of the track and is pushed up and down the track as required to keep the machines supplied. By this system the only lift is of the cement sand and aggregate to the hoppers—the remainder is gravity fed.

One man is required specially to push the truck along the track keeping the machines supplied.

7. Table M, on the following page, gives details of suitable sizes, mixes, etc., for various concrete products.

TABLE M.—SIZES, MIXES, ETC., FOR VARIOUS CONCRETE PRODUCTS

Product.	Approximate dimensions.	Coarse aggregate.	Reinforcement.	Proportion of coarse aggregate to cement.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)
1. Road slabs for wheel track roads	5 ft. × 2 ft. 2 in. × 4 in. One side 4 ft. 11¾ in., other 5 ft. 0¼ in. Ends of slab tapered equally inwards.	1 in. to ¾ in.	Upper and lower layer of No. 8 B.R.C. fabric.	4 to 1	*See* M.E., Vol. V.
2. Sleepers for wheel-track roads	3 ft. 10 in. × 10 in. × 3 in.	¾ in.	2 ½-in. rods longitudinally. 1 ½-in. rod across centre projecting out and bent up at edges to project 1¼ in. above face of sleeper.	3 or 4 to 1	do.
3. Paving slabs	2 ft. 6 in. × 2 ft. × 4 in.	1 in. to ¾ in.	Nil.	3 to 1	For heavy wear.
4. Flooring slabs	2 ft. 6 in. × 2 ft. × 2¼ in.	¾ in.	Nil.	4 to 1	—
5. Wall blocks	From 18 in. × 9 in. × 4½ in. to 9 in. × 9 in. × 2¼ in.	¾ in.	Nil.	6 to 1	—
6. Fencing posts	7 ft. 6 in. to 7 ft. × 4½ in. sq. at base; 3 in. sq. at tip.	⅜ in.	4 ¼-in. rods.	4 to 1	Holed for fence wires.
7. Inclined struts for straining posts	4 ft. 6 in. × 4½ in. × 4½ in.	⅜ in.	4 ¼-in. rods.	4 to 1	Wedge-shaped at top to fit in corresponding notch in upright.

8. Kerbing	3 ft. × 12 in. × 6 in.;	1 in. to $\frac{3}{4}$ in.	Nil.	4 to 1	—
	3 ft. × 10 in. × 5 in.; 3 ft. × 10 in. × 4 in.	$\frac{3}{4}$ in.	Nil.	4 to 1	—
9. Poles	16 ft. 3 in. and 23 ft. 6 in. × 10 in. girth (hexagonal) for 7-ft. length, then 6 in. tapering to 3 in. at tip.	$\frac{3}{8}$ in.	6 $\frac{1}{4}$-in. rods.	4 to 1	Hollow cored.
10. Reinforced concrete piles		Graded from—			
	8 in. × 8 in.;	$1\frac{1}{2}$ in. to $\frac{1}{2}$ in.	4 $\frac{1}{2}$-in. or $\frac{5}{8}$-in. rods	3 or 4 to 1	—
	9 in. × 9 in.;	$1\frac{1}{2}$ in. to $\frac{1}{2}$ in.	4 $\frac{5}{8}$-in. or $\frac{3}{4}$-in. rods	,,	—
	10 in. × 10 in.;	$1\frac{1}{2}$ in. to $\frac{1}{2}$ in.	4 $\frac{3}{4}$-in. or $\frac{7}{8}$-in. rods	,,	—
	12 in. × 12 in.;	2 in. to $\frac{1}{2}$ in.	4 $\frac{7}{8}$-in. or 1-in. rods or 8 $\frac{3}{4}$-in. rods;	,,	—
	14 in. × 14 in.;	2 in. to $\frac{1}{2}$ in.	4 1-in. or 1 $\frac{1}{8}$-in. rods; or 8 $\frac{3}{4}$-in. or $\frac{7}{8}$-in. rods;	,,	—
	15 in. × 15 in.	2 in. to $\frac{1}{2}$ in.	4 $1\frac{1}{8}$-in. or $1\frac{1}{4}$-in. rods or 8 $\frac{7}{8}$-in. or 1-in. rods.	,,	—

In every case sand should be added as necessary to fill the voids in the coarse aggregate.

8. **Manufacture of reinforced concrete piles.**—Owing to their bulk and weight reinforced concrete piles would normally be constructed as near the site where they are required as possible.

Forms for concrete piles are very simple and require no explanation.

The reinforcement should be kept $\frac{3}{4}$ to 1 in. from the faces of the piles.

As much cover as possible is desirable to protect the steel from corrosion, but from the mechanical point of view the nearer the steel is to the face of the pile the more efficient it is ; and with a properly graded concrete the above figures are sufficient.

The main reinforcement can be tied together in a variety of ways, and simple forms of linking are illustrated in Pl. **103,** Figs. 4–6.

The average spacing of these links should be about equal to the least core diameter of the pile, but for the end 2 to 3 ft. at both top and toe it should be reduced to as close as 2 or 3 in.

Linking should stop 2 in. below the top of the pile.

The concrete must be carefully graded, so as to ensure as dense a mix as possible, and it should be as stiff as consistent with easy and efficient tamping.

Concreting should be done in one operation to avoid a possible weak joint, and the completed pile kept damp while curing.

Shoes will nearly always be required, and suitable types are illustrated in Pl. **103,** Figs. 2 and 3.

To ensure straight driving they must fit symmetrically.

Piles will usually be fitted with a helmet for driving, to avoid possible damage to their heads.

9. **Water content.**—The amount of water required in concrete for various concrete products depends on a variety of conditions, *e.g.* the size of the coarse aggregate, the shape and nature of the solids, their power of absorption and solubility, the grading of the aggregate, the aeration of the cement, the temperature of the mixing water, and the amount of working and mechanical mixing.

Generally speaking the amount of water required to hydrate the cement is comparatively small, 22·5 per cent. by weight of the cement, and any increase over this amount will weaken the concrete. For concrete products, however, particularly when reinforced, the ruling factor is the workability of the mix. This is best determined by a slump test, and a 2 to 3-in. slump should give good working results.

This should be attainable with a proportion of 18 to 24 gals. of water per cu. yd. of material.

Alternatively, a water/cement ratio by weight of 50 to 65 per cent. should be equally satisfactory.

10. **Purity of water.**—Although clear water is required the purity is of little importance. Provided impurities such as sulphates, sodium chloride or sulphate, etc., do not exceed 1 to 1½ per cent. the concrete is unaffected. In larger quantities they only produce correspondingly proportional reductions in the strength of the concrete. Sea water, however, although only reducing the strength of the concrete by 10 to 15 per cent., may cause corrosion of the reinforcement, and should be avoided, and other impurities in excess may have the same results.

Trade wastes generally have little harmful effect—at the most reducing the strength of the concrete by some 10 per cent., except for sugar and similar compounds, which must be avoided.

Concrete made with impure water will increase in strength by 1 per cent. for every additional 1 per cent. of cement added.

CHAPTER XXVIII

STONE QUARRIES

146. General considerations

1. In any campaign stone is likely to be required in very large quantities for road work, and in much smaller quantities as aggregate for concrete and various concrete products. The various species of stone, and their suitability for various purposes, are considered in Military Engineering, Vol. V.

Generally, however, there will be little choice in the selection of the stone to be quarried.

Geological formations are usually fairly constant over very large areas, and quarries will have to be worked where they can be found and where suitable means of access can be provided.

2. The primary consideration in opening up a quarry is the amount of stone likely to be required, and this in turn is governed by the method of transport from the quarry.

It will nearly always be found far easier to produce stone than to get it away from the quarry.

3. In a country with a well developed railway system it will usually be best to concentrate on one or more large quarries, and to undertake the transport of stone by broad gauge line to various distributing centres.

4. Where for one reason or another broad gauge collection and distribution is impossible other means must be found.

These will be by light gauge railway, by lorry, by horsed transport, or by locally hired transport.

The capacity of any of these methods is normally so limited that it will be found impossible to work any individual quarry on a large scale, and it will be necessary, therefore, to open up a series of smaller ones situated within reasonable distances of the roads, etc., which require the stone.

5. For economical working these distances should not exceed the following :—

With broad gauge railways	150 miles
,, light railways	25 ,,
,, lorries	25 ,,
,, horsed vehicles	4 ,,

6. The two extremes were well illustrated in the Great War in France and Salonica.

In France some quarries were called on for an output of

2,000 tons a day, which was dealt with entirely by broad gauge railway.

In Salonica, on the other hand, on the Seres road of approximately 70 kilometres in length, quarries were opened up at kilometres 6, 23, 39, 48 and 64, and motor lorries, limbers, A.T. carts and local horsed vehicles were used for the transport of stone. In no case did the production exceed 400 tons a day, and in most it was between 200 and 300 tons.

7. Other things being equal, the easiest quarries to work are those with high faces and little overburden, and with the strata inclined towards the working face.

With strata dipping away from the face the overburden is likely to increase rapidly as the work proceeds, until the labour of moving it becomes excessive and very uneconomical.

8. The whole process of working a quarry is enormously simplified if gravity feeding can be arranged from the quarry face to the crushers, and from the crushers to the transport vehicles ; and, if the working face is sufficiently high, it will often be worth while sacrificing many feet of its height to obtain this. Conversely, if it can be avoided, the quarry face should never be worked in a downward sloping direction, as this involves haulage of material up to the crushers, and will probably necessitate pumping away accumulations of water from the bottom of the quarry.

As with every other manufacturing activity on active service if existing quarries can be found in the theatre of war it will always pay to make use of them, either by placing contracts for the stone required, or by taking them over for working.

147. Preparation of a quarry

1. The site having been selected, the first step is to lay bare the surface of the rock, and to clear away the overburden. For this picks, shovels, crowbars, barrows, light planking and a tramway and tip trucks are required.

The front soil can usually be made use of for building up platforms for the crushers and generally levelling the area : but the overburden must be carried away to the side or rear, well clear of any possible future extension of the workings. The process of clearing the overburden will probably be continuous all through the time the quarry is working, and as a general rule the rock should be kept clear for at least 20 ft. behind the working face.

2. As soon as the stone is exposed, quarrying can be begun on a small scale, and after a few hundred tons have been removed it should be possible to estimate the capacity of the quarry, and to decide on the full plant to be installed.

3. Although at the start it may be necessary to drill by hand, as soon as possible compressed air plant should be installed. A suitable equipment for the early stages would be a small semi-portable engine of about 25 b.h.p. direct-coupled to an air compressor with a capacity of about 100 cu. ft. of free air a minute. This plant will drive one drill with a bore of 2½ in. by 2 in. stroke, using a drill steel with a 1¼-in. diameter bit. Two drills should be available for working alternately at different parts of the face, but no attempt should be made to work both simultaneously off the plant as this merely results in loss of pressure, and consequently of speed.

Little progress will be evident at the start, as outcrops, etc., must be cleared away in order to obtain a good working face.

4. Spasmodic drilling and blasting must be avoided at all costs. A good and regular output can only be obtained from a clean and vertical working face, and production will suffer heavily at later stages if this is not attained at the outset.

148. Drilling

1. With rock drills carrying best quality steels of 1¼-in. diameter with rose or cross bits, drilling with compressed air will be found easy compared with hand drilling, and about ten times as fast. Depths of 6 ft. can be drilled without choking. The speed of drilling is 4 to 6 in. a minute, or allowing for the changing of bits, etc., 6 ft. an hour.

Drilling should be started with a short 18-in. bit, which should be changed for a longer one when the hole is down to the shank of the steel, and so on until the required depth is reached.

2. The number of holes to be drilled and their depth depends on a variety of circumstances, and only experience will show which is the best number for any particular quarry, but in the early stages of developing a quarry holes should be 6 to 8 ft. apart, and about the same in depth. Holes should be drilled across the whole of the working face, and should be well staggered about the face and inclined slightly downwards.

It is obvious that the results of blasting will be more effective if all these holes are detonated at the same time.

When the holes are ready for the charging, they should be cleaned out by compressed air. This can be done by inserting into the hole a length of rubber hose, about 6 in. shorter than the depth of the hole, coupled to the air pipes, and blowing out the dust, etc.

If compressed air plant is not available, the holes must be cleaned out with small scoops of a size to reach to the bottom of the hole.

149. Blasting

1. A definite system of blasting should be instituted at the outset, and a special gang employed on the work.

These men make up the charges complete with detonators and time fuze, while drilling is going on, and place, tamp and fire the charges during the meal hours of the drilling parties.

2. The charges vary from 2 to 16 oz. of high explosive such as dynamite, gelignite, blastine, etc. The amount of the charge varies with the nature of the rock and the class of stone required, *e.g.* whether for road metal or for building, and can only be determined by experience.

Normally it is wiser to over-estimate the amount required, as any waste of explosive is offset by a saving of time in drilling.

In certain cases, however, it will be found that small charges are more effective than big ones.

3. Tamping is done with sand or clay, lightly pushed in for the first few inches, and then rammed in tight till the hole is filled.

4. Firing will normally be by fuzes, which are best lit with a torch, and by one or two special men. To give them time to get round in comfort the fuzes should be graduated in length, the short ones being on the outside and lit last.

Owing to the danger from unexploded charges it is essential to put a thoroughly reliable N.C.O. or man to count the number of charges and the resultant number of explosions.

5. In the event of any miss-fire the faulty charge must be traced, and, if it cannot be withdrawn, a second charge should be fired alongside.

Boards carrying a notice as follows should always be placed in prominent positions in a quarry :—

Miss-fires

DON'T touch a miss-fired hole.

DON'T, when blasting with safety fuze, approach a miss-fired hole until a safe time has elapsed.

BORE a second hole at a SAFE distance and well clear of the miss-fired hole.

SEARCH the debris for detonators and charges.

With native quarrymen these notices should be translated into the vernacular.

6. After a certain amount of blasting it will be possible to determine more accurately the probable capacity of the quarry, and the scale on which it should be operated.

150. Equipment

1. The first consideration is the estimated amount of stone required for the particular area which the quarry will eventually feed.

The daily output will be governed entirely by the amount which can be got away by the available means of transport, as, although certain accumulations of stone can be made on the quarry floor, any accumulations of crushed stone will usually mean double handling and consequent waste of effort.

The maximum output for which transport will be available is not likely to exceed 2,000 tons a day—which was the figure maintained by some of the quarries in France during the Great War.

2. The equipment necessary for an output of this dimension would be :—

i. **Compressors.**—4 each of capacity of 600 cu. ft. of free air a minute. One of these would be a stand-by. Each compressor would require an engine of about 120 b.h.p.

ii. **Engines.**—Steam plant is undoubtedly best for general quarry working, owing to its capacity for taking overloads, but it involves large stocks of coal and requires water ; and the steam by day and the glare from fires by night form good guides to hostile aircraft.

If I.C. engines are installed the cold starting horizontal cylinder type is suitable up to 75 h.p. per cylinder. If adequate supplies of electric power can be made available it may be desirable to instal motor driven compressors and even crushers.

With the compressors and engines air receivers to work at a pressure of 100 lb. per sq. in are required ; also a large quantity of W.I. piping, 6 in. and 4 in. for mains, and 3 in. and 2 in., 1 in. and $\frac{3}{4}$ in. for branches and distributors, as well as an ample supply of pipe fittings.

iii. **Rock drills.**—Each compressor would be capable of working 7 or 8 Jackhammer drills, so that, allowing for casualties, some 35 should be provided. The Ingersoll Rand or similar pattern is a suitable type.

Large tripod drills for main drilling will also be required. Allowing 4 or 5 for each compressor and a proportion of spares, 20 should be kept in stock.

The tripod drill is very adaptable and can be readily set up in almost any position. The usual working pressure is 80 to 100 lb., and it can drill a 3-in. hole in limestone at the rate of 6 in. a minute to a total depth

of 24 ft. The bore and stroke of such a drill is approx. 3½ in. by 7 in., and the h.p. required to drive it 20 to 25, with a consumption of free air of about 150 cu. ft. a minute.

iv. A large stock of spare drill steels both large and small should be kept, and a drill sharpener should be provided. Hand sharpening is very slow and often inaccurate, and in a large quarry delays production.

A suitable type of drill sharpener is one worked by compressed air at a pressure of 100 lb. per sq. in. and consuming from 80 to 100 cu. ft. of free air a minute. It should be capable of resharpening bits of diameter from 1 to 3 in. at the rate of 40 to 60 an hour, and of reforming new bits of the same diameters at the rate of 20 to 30 an hour.

This type of machine should be fixed to a resilient base such as a cross of railway sleepers, as on a concrete foundation it is liable to fracture at the base.

151. Quarry transport

1. Railway rolling stock, with all the necessary tools and appliances, will be required, including locomotives (steam or oil). Rails, sleepers, points, crossings, etc., will be needed in large quantities, both to repair damage caused by blasting and for extensions, as the size of the quarry increases.

The locomotives may often require turning, especially if feeding the crushers on an inclined ramp. Turn-tables are costly and liable to damage, and it is preferable therefore to lay a triangle for turning purposes.

2. Travelling cranes and mechanical shovels with a lifting capacity of 5 tons will be required at the rate of one to each 30 to 50 yds. of face. Strong ironbound skips should be provided with each crane, and side tipping wagons for the conveyance of the stone to the crushers and tipping direct into the crusher hoppers.

152. Crushing plant

1. The crushers should be capable of dealing with 40 to 60 tons an hour, or, allowing for various losses, etc., 500 to 750 tons a 16-hour day; 4 of these will be required for an output of 2,000 tons a day. The horse-power to drive them can be put at 2 per ton-hour of stone, to which should be added at least a 25 per cent. margin for overloads, etc.

Steam engines are the most suitable, but reliable I.C. engines of 60 to 80 b.h.p. will do the work.

If the quarry has its own generating plant the crushers could be driven by suitable motors, but in quarry work it is seldom advisable to concentrate all power plant in one place.

2. In most quarries springs are likely to be found in the course of blasting, and pumps will be required for removing the surplus water, and keeping the quarry floor as dry as possible. To facilitate this drains leading to one or more sumps should be dug.

Some of this water can be used for washing the stone as it passes through the crushers. This can be done in a simple manner by playing a stream of water from a perforated length of pipe on the stone as it passes through the crusher jaws.

153. Small gear

Small tools such as barrows, shovels, picks, hammers, crowbars, forks, rakes, etc., will be required in large quantities, and " Jim Crows " or railbenders should also be included.

154. Lay-out of the quarry

1. The power house, oil store, repair shops, etc., should be erected at a distance from and well clear of the site of any future blasting.

A position to the right or left rear of the quarry is suitable, as it is quite possible for pieces of stone weighing 1 cwt. to be hurled 300 yds.

2. Owing to the heat generated in compressing air, the air receivers should be outside the engine house and away from any oil supplies.

3. The main pipe line from the air receivers to the quarry should be laid without sharp bends, and should be fitted with a T-piece and plug or cock every 50 yds., and with a drain cock wherever the pipe drops, to clear away accumulations of water from the pipe.

4. With long pipe lines reheating the air increases the capacity by about 30 per cent. This should be done as near the drills as possible, and a simple method is by fitting sleeves of larger diameter pipe over the air pipe, *e.g.* a 6-in. sleeve over a 4-in. pipe. The sleeve can be heated by building a fire round it, and will save the pipe itself from damage.

Branches are laid from the air mains to suitable points to which the jack-hammers can be connected with flexible hose.

5. The crane track should be laid along the quarry face, at a distance from it equal to the radius of the crane jib, and another track outside it also at the same distance to hold the railway wagons waiting to be filled up.

This track should connect with lines leading to the crushers, water tanks and overburden dump, and also to the main line out from the quarry. Sufficient length of rail should be left

at the end of the quarry to take 8 tipping wagons, *i.e.* two for each crusher, and the loco-tracks should be looped into the crane tracks so as to permit of moving any cranes not under power.

6. The crushers should be erected on high concrete blocks, so that the lowest part of their revolving screens is well above the highest type of wagon in use on rail transport. 3 sets of rails will be required under the revolving screens to allow of trucks being placed to catch the dropping stone.

The furthest out truck takes the large macadam rejected by the screens, the centre one the graded size, and the innermost one the small splinters and chippings for use as road toppings or for the manufacture of concrete products (*see also* Sec. **145**).

7. Unless the configuration of the ground permits of the siting of the crushers well below the level of the quarry floor, in which case gravity feed can be arranged, an inclined ramp will have to be built up to the crusher platform. This should be wide enough to take 2 sets of rails. Each crusher should have a feeding hopper of 5-ton capacity, so that side tipping wagons, if provided, can discharge their whole load into any one hopper.

8. An alternative method of feeding is the endless chain railway, in which the turn-wheel is erected at the top of the ramp and the guide-wheel at the bottom and slightly below the quarry level, so as to get a gravitation run from the quarry floor to the bottom of the ramp leading to the crushers. These wheels are designed to take the size of the chain link in use, and the wagons are fitted with slotted plates at front and rear to take the chain (Pl. **104**).

The wagons gravitate or are pushed on to the chain, which automatically picks them up, and they are released at the crusher hopper by the chain having a slight rise to the turn-wheel. The wagons are then tipped into the hoppers, and then, running past the crushers in a semi-circle, are picked up by the travelling chain and conveyed to the bottom of the ramp.

If the ramp and gravitation rail are properly constructed, the impetus gained when the empty wagon leaves the chain should be sufficient to take it up the slight gradient on to the quarry floor.

9. Magazines will be required for the storage of explosives. A dry site well away from the workings should be selected, and the magazines built preferably into the side of a bank or as dug-outs. They should be covered with sufficient earth to maintain a fairly constant temperature inside and to prevent freezing.

155. Lighting of the quarry

The alternative forms are electric lighting, oil and acetylene. Under war conditions, it should be possible to extinguish all the lights in a quarry at a moment's notice, and electric lighting is the only method which permits of this. It has the disadvantage of vulnerability to damage, especially from blasting, and to minimize this spare poles ready crossed and insulated should be kept ready for erection; 500-watt gas filled lamps are the most generally suitable for quarry working.

The breakage of lights can be avoided to some extent by lowering them during blasting into pits sunk at the bases of the poles.

Overhead mains are easily repaired, and it is seldom worth the trouble of cutting trenches in the rock in which to bury cables.

156. Personnel

1. No estimate can be given of the number of men required for working a large quarry, as it depends entirely on the conditions prevailing in the particular quarry. When in full production with good organization the output should approximate to 4 tons per day per man actually employed on quarry work proper.

The following personnel will always be required :—

i. **Engine drivers**—fitter drivers in the power station, engine drivers for the cranes, locomotives and crusher engines. The power station staff particularly should be carefully selected, as the work will be unfamiliar to most men.

ii. **Fitters and turners** for overhauling and repairing rock drills. Drills must be overhauled in the shop; there is too much dirt on the quarry floor for the work to be done there. All drills should be marked and called in periodically for inspection and overhaul.

iii. **Smiths,** who should be trained in the use of the drill steel sharpener. If there is no sharpener, a number of smiths should be employed solely on the sharpening and tempering of the drills, the others being put on the general smithing work.

iv. **Pipe fitters and mates** for repairing, extending and moving air pipe lines, etc.

v. **Carpenters**, for repairs to crusher hoppers, crane skips, tipping and railway wagons, etc. Strong rough carpentering is wanted, and not fine or precision work.

vi. 4 **men for each shift for each crusher,** for tipping wagons, coupling on full trucks to locomotives, and making up trains for dispatch.

vii. A **platelaying gang,** to keep the various tracks in order.

2. The quarry force should be split up into various gangs, *e.g.* drillers, blasters or shot men, clearers, loaders and various labouring detail.

The least skilled can be employed on the removal of the overburden. It will be found that a very large quantity of the loose stone resulting from a blast is too big for the crusher. The larger blocks may have to be drilled and blasted, but the smaller ones can easily be broken up by hand. A gang of hammer men will therefore always be required in a quarry for this purpose.

157. Production in bulk

1. To obtain bulk production a high vertical face and deep drilling are required. Large blasts give much better results than small ones, and the extra time spent in drilling and preparing for them is amply repaid:—

i. The drills for a large blast should be placed along the quarry floor and along the top of the face and the requisite distance back from the edge.

3 or 4 of the tripod drills should be drilling on the quarry floor, and 8 or 9 drilling vertically down from the top and 16 to 20 ft. back from the edge.

ii. Drills should be spaced at fairly equal distance, and with 8 or 9 holes better results will be obtained if 2 of them (Nos. 3 and 7) are chambered for larger charges. This can be done by placing 4 to 6-lb. charges at the bottoms of the 24-ft. holes, tamping and firing.

iii. After cleaning out these holes should take a charge of 40 to 60 lb. according to the class of stone and size of hole.

The other holes will take from 10 to 15 lb. of high explosive.

iv. Some of the boulders resulting from the blast will be up to 6 or 8-ft. cube, and will have to be reblasted before they can be handled.

The requisite size for the crushers is about 1-ft. cube.

2. As the quarry increases in depth, the face will get higher, and it may become necessary to work in a series of steps each within command of the longest drills in use, *i.e.* 20 to 24 ft.

Upper steps must not be taken so far back that the stone

on blasting will not fall to the quarry floor, unless it is intended to work the upper floor independently and to send the stone to the crushers by aerial ropeway.

158. Small quarries

1. It will be appreciated that the procedure described in Secs. **147** to **157** is only possible for large scale production where transport by broad gauge railway can be provided.

In very many cases this will be impossible and the only means of getting away the stone will be by lorry, light railway or horsed vehicle.

Not only will this in itself limit the scale of working, but the lack of means of transport of heavy plant to the site will necessitate the use of smaller quarry gear. It may be taken for granted that all this gear will have to be either portable or mobile. Compressor plant, if available at all, will be of small capacity, tripod drills will be out of place and impossible to work, and the crushers will be mobile, of capacities probably not exceeding 10 tons an hour, and worked by semi-portable engines.

2. In extreme cases all drilling may have to be done by hand, and stone breaking as well.

In such cases it is usually best to prepare a track on to the quarry floor itself for use by whatever road transport is available, and to transport the large stone to the roadside, or to where it is required, and break it up into road metal on the site.

A large number of stone hammers will be required, and the output of road metal can be put at $\frac{1}{2}$ to $1\frac{1}{2}$ tons per man per day according to the toughness of the stone.

Stone breaking is a form of employment which readily lends itself to piece-work.

3. Normally, however, it may be anticipated that compressors and crushers will be available.

The need for flexibility to meet the heavy and sudden overloads which occur constantly in quarry work, and the necessity for plant to be mobile or portable, renders it more than ever desirable that steam plant should be available. In view, however, of the increasing tendency to manufacture heavy oil plant in substitution of steam plant, it is possible that the former only will be available in a future war. In many theatres of war shortage of water and means of transport for fuel may be the deciding factors in favour of heavy oil plant.

If the latter is used it is essential to allow for an ample margin of power (up to 100 per cent.) over the rated requirements of the plant installed.

159. Lay-out of small quarries

1. The system of working and the lay-out will follow the general principles already indicated.

Transport from the quarry floor to the crusher platforms will usually be by decauville skip wagons (of average capacity of 1 ton) and man-handled, unless a gravity feed can be arranged. In such cases an endless rope system, by which loaded trucks going down pull up the returning empties, is convenient and easily worked. Skips are connected by a wire rope, which passes round a stout pulley on the quarry floor. The rope should be kept off the ground by rollers at frequent intervals. Good braking is required either on the pulley or on the skips, and, if this is provided, rakes of 6 to 8 trucks can be sent down at a time.

Alternatively, if the slope is sufficient, the stone can be slid down a wide chute, which should be lined with sheet metal.

Unless, however, the slope is about 30 deg. the stone will jamb on the chute and will have to be eased down by hand in places.

2. i. Crusher screens will seldom be justified, and crushers will normally be fed by hand.

ii. In view of the necessarily spasmodic working of mechanical or horsed transport large bins are required to hold the crushed stone until it can be loaded into the transport vehicles.

Without these, the crushers must either stop work while the transport is away or the stone will accumulate in heaps on the ground and have to be loaded by hand into the vehicles.

iii. The capacity of the bins should be not less than 15 to 20 tons for each crusher (*i.e.* 2 hours' supply) and they should be so constructed that the stone slides to funnel-shaped openings at the end discharging on to the floor of the vehicle. This opening can easily be closed with a hinged or sliding flap, as very little pressure is required to jamb up the stone in the bin.

iv. The crusher platforms must therefore be at a considerable height above the road level, to give sufficient space for the bins.

The platforms can be suitably built of squared timber, but the bins must be sheeted with metal.

3. Vehicles transporting stone must also be lined with metal, and, if lorries are used, they should be tipping, if possible, or alternatively temporary hopper bodies allowing of discharge on either side should be constructed on them. Either form of transport presupposes the definite allocation of transport for the transport of stone, and this will be found

to be an essential if a steady output is to be maintained and road work is to proceed rapidly and with regularity.

160. Types and performance of quarry gear

Commercial types of stone crushers required for quarry working and their performances are considered in Chapter XXXV.

A typical lay-out for a large quarry is given on Pl. **104.**

CHAPTER XXIX

FACTORIES

161. Ice factories—General considerations

1. In climates where great heat is experienced a daily supply of ice may become necessary, first to hospitals, and possibly later to the troops. It is desirable that the policy should be settled definitely at the outset—scales of issue being laid down on broad lines by the Q.M.G's. branch—before plans of production are formulated or plant ordered.

Changes of scales and requirements should be notified at least six months before the increased output is to be obtained.

As a rough guide plant of the nominal daily capacity of 4 lb. for each hospital bed will probably supply the requirements of hospitals in an area and possibly give a small surplus for messes, etc., but this figure should only be used after full consideration of local conditions.

2. In large towns in the tropics local ice plants may be found, but these should not be relied on for the supply of military needs unless it is certain that they are in working order and good condition.

3. Owing to the difficulty of obtaining skilled supervision, it will normally be better to group together, as far as possible, all ice-making plants in central ice factories at selected stations on the line of communication. This centralization, provided suitable transport can be made available, will probably prove more efficient than the installation of a plant at every station where ice is needed.

The supply of ice to forward troops presents many difficulties, but, since the period during which ice is needed will probably coincide with the intervals between actual operations, the best policy will probably be to begin about two months before the ice issue season starts the erection of forward ice plants in localities as far forward as the military situation renders safe. Duplicate plant may be held available for leap-frogging forward, if necessary or desirable.

For this, and on the score of mobility, small unit plants are the best, but in base areas large units are more economical, and save in personnel to run them.

162. Ice factories—design and plant

1. The principles of refrigeration, and the best materials for insulation are investigated in Chapter XXIV.

It should be borne in mind that the rating of machines

for ice-making is normally only 50 per cent. of that for refrigeration.

2. A large and uninterrupted supply of cooling water is very desirable for the satisfactory operation of the plant, and is usually the deciding factor in fixing the site of the factory.

Shortage of water may be met by the use of a cooling tower or evaporative condensers, but this may reduce the output of the plant by as much as 30 per cent. of its nominal capacity, owing to the rise in the temperature of the cooling water.

3. A plant of the nominal daily capacity of one ton of ice under tropical conditions is probably the most suitable standard unit for use in the field. To have an assured daily output of one ton of ice, however, two of these units should be installed.

Larger units than these are too heavy for easy transport in undeveloped countries, but may be required at bases, etc.

In Mesopotamia units rated at three tons output were installed on barges and could therefore be moved about the country.

4. There are two methods of working an ice plant, the "continuous" and the "batch." In the continuous method working is carried on steadily throughout the 24 hours, an even brine temperature is maintained, and cans are lifted out in rotation. In the batch method, cans are lifted, emptied and refilled at the same time. The plant is then started up, run for a certain period, and then closed down, the final freezing being carried out by the cold stored up in the brine.

Usually only one batch is made in each 24 hours.

The output by the batch method is half or less of that by the continuous method, but labour and power charges are reduced to about one-third.

Continuous working would be adopted normally under active service conditions, and, where possible, plant would be duplicated to insure against breakdown.

Electric power is most desirable; failing this, slow-speed oil engines are more reliable than high-speed petrol-paraffin engines. The former, however, are cumbersome and, where the plant has to be moved by road, the latter should be provided.

High-speed heavy oil engines are, however, now coming on to the market.

5. Ammonia compression machines are the most suitable for military requirements, and other systems should not normally be installed. Small methyl-chloride sets, of which the "Frigidaire" is typical, may be useful where extreme portability is required.

6. There are several systems of ice-making, but the "can" system is now almost exclusively employed, and is undoubtedly the most suitable for military requirements. In this system the water to be frozen is put in cans, which are placed in brine, which is kept at a low temperature.

The water for ice-making must be approved by the medical authorities, and all precautions must be taken to prevent it from becoming contaminated.

Spare G.I. ice cans will be required as well as engine spares.

7. The time taken in freezing varies roughly as the square of the thickness of the ice, and is approximately as shown in the following table, with brine at 17 deg. F. :—

Thickness of ice in inches	5, 7, 11 and 12
Time of freezing in hours	12, 22, 45 and 55

The time of freezing, however, varies considerably with the efficiency of the brine circulation system, and may exceed the above figures in a badly designed plant.

8. The brine tank should be cooled by at least 250 r.ft. of 1¼-in. piping or 180 r.ft. of 2-in. piping per ton of daily ice-making capacity. The brine must be circulated in the tank.

9. Storage for ice should always be provided, and its size requires careful consideration.

A minimum of 10 days' full supply of the factory should be in reserve. This will not only allow for daily variations in the issues, but will provide for breakdowns in the plant. It can also be made use of for general issues on a small scale, or for increases in the authorized scale during spells of exceptionally hot weather.

10. A typical lay-out of a 20-ton ice factory is given on Pl. **113**.

11. A mobile ice-making plant is illustrated on Pl. **114**.

This is fitted to a P.E. lorry, but can be adapted to an ordinary lorry or horse wagon by the substitution of a small petrol engine for the electric motor shown.

A similar type of plant could also be fitted to a railway wagon.

With brine at 17 deg. F. the output of this plant, working continuously, would be ½ ton of ice in 24 hours, or, working on the batch principle, 3½ cwt. a batch.

A 4 h.p. motor and a machine of 30,000 B.Th.Us. per hour rating would be required.

The tank is divided into compartments, and each is fitted with a ship's pattern watertight lid.

Each can holds a 38 lb. block of ice, and, when in the tanks, is sealed by the lid. The thawing out tank is connected to the

cooling water tank and can be emptied by the circulating pumps and refilled from the tank when necessary.

The cans can be refilled from the bottom of the fresh water tank.

The circulating water pump is belt-driven from the compressor shaft.

The complete installation would weigh between 2 and 3 tons under working conditions.

163. Bakeries

1. Although at the beginning of any campaign field bakeries worked by hand will be installed, it is probable that in most cases these will be replaced or supplemented by power bakeries as soon as conditions justify the change.

Field bakeries will be equipped either with an approved type of portable oven, or with the " Aldershot " pattern oven, and in either case the engineer work required in their installation is simple and requires no further elaboration.

The installation of power bakeries is somewhat more complex.

2. The engineer work required in connection with their establishment, some of which will also be applicable to field bakeries, may be grouped under the following heads :—

i. Provision of road and rail access, internal communications and loading and unloading facilities.
ii. Erection of buildings.
iii. Installation of plant.
iv. Accessory services—water supply, drainage, lighting, and accommodation for personnel.

If a new bakery had to be built it is improbable that any but a single story building would be erected.

3. Pl. **115** shows the lay-out of a bakery designed to produce 100,000 to 125,000 lb. of bread daily, working 3 8-hour shifts. This may be taken as a suitable unit installation, which may be modified according to requirements of output.

4. Accommodation will be required in adjoining buildings for :—

Additional flour, flour-sweepings and sack stores.
A brew-house (if it is necessary to use hop yeast instead of prepared yeast).
A bakery office.
A baker's changing room.
Lavatories and ablution places.

5. The advice of consulting engineers will normally be sought as to the types of plant most suitable for a given output

in a particular climate; while the steady introduction of new improvements in modern bakery plant renders any attempt to lay down machinery details inadvisable.

6. Existing buildings can frequently be adapted as bakeries without great difficulty. In such cases three storied buildings, if sufficiently substantial, lend themselves to ready conversion on the following lines :—

On the second floor—flour storage.
On the first floor—dough room.
On the ground floor—bakehouse, bread store and offices.

Flour must be raised to the second floor by mechanical means, after which all materials gravitate to the lower floor with a minimum of labour.

7. As an illustration of actual practice in the field the following particulars are given of the Dieppe bakery, which was converted to a power bakery in May, 1915.

8. **Dieppe bakery.**—

i. Two steel sheds, each 70-ft. span, were placed side by side, with a 3-ft. covered space between, to form the main building, 143 ft. by 325 ft. This was floored throughout with concrete: the sides and roof (with skylights) were of corrugated iron.

ii. The arrangement of the bakery is shown on Pl. **116**.

iii. The machines were driven, and the building lit and ventilated by electricity. Motors of the following capacity were installed :—.

For the dough-mixing machine	1–20 h.p.
„ each divider	1– 6 „
„ „ dough moulder	1– 3 „
„ the ventilating fan	1– 5 „

iv. Boilers were installed in the centre of the building, and cold water was laid on from the town water supply.

In this connection it should be noted that heating arrangements and a hot water supply are only necessary in cold climates, especially if there is any chance of the temperature going down to or below freezing point.

v. Three separate flour stores—135 by 50 ft., 135 by 60 ft. and 140 by 80 ft.—were constructed, with concrete floors, timber or steel framing, corrugated iron sides and roofs (with skylights) and sliding doors. Sack and flour sweepings stores were also provided, in addition to a bakery office, a baker's changing room, lavatories and ablution places.

These are not shown on the plate, which only gives the main building.

164. Laundries

1. In war the cleansing service as a whole will be the responsibility of the Royal Army Ordnance Corps. The Director of Hygiene in the field (or his representative) will advise as to needs, location, disposal of effluents, choice of sites and water supplies.

2. Under certain conditions, *e.g.* a prolonged campaign accompanied by a large increase in the original strength of an expeditionary force, and where there is a concentration of hospitals and convalescent depots, etc., in a base area, it may prove advantageous to instal fixed power laundries, on the lines of those installed in certain areas in France during the Great War.

3. The size and capacity of the laundry, and the machinery installed, would depend on the number of articles to be washed each week, but the same general principles would govern the lay-out, whatever the capacity.

The installation would include the following :—

i. **Receiving area for dirty clothing.**—The clothing would be passed through a row of steam disinfectors, on the far side of which racks would be installed, from which the clothing would be issued to the washing machines.

ii. **Washing area.**—This would be equipped with one or more rows of washing machines, each row consisting of from five to eight washing machines driven off shafting by a 20 h.p. steam engine or electric motor. In large laundries, two or more rows of machines might be driven off a larger engine, and one or two of the machines should be of smaller size to deal with special work. On the far side of these machines would be grouped a series of hydro-extractors, on the scale approximately of one extractor to two washing machines. Alternatively the hydro-extractors may be interposed between each pair of washing machines, and driven off the same shafting.

In order to give greater flexibility to the lay-out where electric current is available the various machines may be fitted with an independent motor drive.

iii. **Drying area.**—The bottle-neck in any laundry will usually be the arrangements for drying. In theatres of war where the climate is suitable, open-air drying on clothes lines is by far the simplest and most economical, and would be resorted to.

In other cases efficient drying chambers and/or machines must be installed.

The principle underlying all systems of artificial drying is to pass a continuous stream of hot air through the articles to be dried, and to extract it when saturated with moisture. Heated air in itself, unless changed, will not extract moisture from wet clothes. The current of air may be obtained either by natural draught, by pressure fans, or by extractor fans, or by a combination of both.

To heat the air the best method is to pass it through steam heated tubes or radiators.

Air can also be heated by passing it over a cast-iron stove burning waste products (Canadian type of stove), and this may be a suitable method in certain circumstances.

The most elementary arrangement is perhaps to fix a steam radiator in the wall with a fan behind it.

The size of individual compartments of a drying chamber should be limited to that required to deal with the output of one washing machine.

Where the complete equipment can be obtained from the United Kingdom continuous hand fed conveyor driers would be installed on the scale of one drier to each extractor. These might be supplemented with half their number of calenders, and sock-driers on the scale of one to two calenders.

iv. **Drying rooms.**—Where continuous driers are installed, drying rooms would be built in conformity with the makers' plans for these machines.

In other cases they must be improvised.

Drying rooms must be small, each one at the most dealing with the output of one large washing machine, and constructed with matchboarded sides and ceiling, and tight-fitting doors or closing shutters at either end. Articles to be dried might be carried either on improvised "horses" running on rails through the drying room, or on some form of coat hook, sliding on and suspended from rails in two tiers and extending through the drying room. In either case no continuous system of drying could be employed, and the "batch" system would be resorted to. With an efficient installation the time required for drying one charge or batch should not exceed 1½ hours.

Hot air would be driven by a powerful fan through a battery of steam tubes or radiators and led in

trunks along the floors of each drying room and extracted in a similar way by trunks along the ceilings. Trunking should be so arranged that the hot air is distributed evenly throughout the chamber. This is best arranged by having inlet and exhaust holes opposed to each other at intervals in the respective trunks, which should themselves run down the centre line of the floors and ceilings in each chamber.

v. **Boiler house.**—The boilers should be of the capacity required for the plant installed.

vi. **An adequate supply of water.**—If necessary, with water softening plant (*see* para. 9, below).

4. A typical installation for 90,000 men might therefore comprise the following :—

i. **Plant.**—

Washing machines, 450 shirt capacity (9 ft. overall)	No.	10
Washing machines, 120 shirt capacity	,,	2
Hydro-extractors, 3 ft. diameter ...	,,	5
Continuous hand-fed conveyor drying machines	,,	5
Sock-drying machines	,,	1
Calender drying machines (for sheets, etc.)	,,	2

ii. Assuming that electric power is available a convenient arrangement would be to group four washing machines and two extractors on a shaft some 50 ft. long driven by a 20 h.p. motor, each extractor being placed between a pair of washing machines. Alternatively an independent motor drive could be given to each machine (*see* para. 3, ii, above).

iii. If continuous driers were not installed 10 drying rooms, approximately 10 ft. by 10 ft. by 7 ft. high, would be adequate to deal with the output of the laundry.

iv. Requirements of steam and water could be put at :—

½ gal. of water per shirt unit for washing.

½ lb. of steam (at 50–100 lb.) for heating water, and up to 2 lb. of steam per shirt for drying ; making a total of 24,000 gals. of water and 120,000 lb. of steam per day for 90,000 men, *i.e.* a total water consumption of some 150,000 gals. a day.

A working day may be taken as 10 hours.

5. The following minor equipment and fittings will also be found necessary for the efficient working of a large laundry.

Laundry trollies.

Hampers.

Bins for sorting.
Racks for packing.
Flat irons.
Presses.
A marking machine.
A collar machine.

6. Special steps may have to be taken to deal with the effluent. In exceptional cases it might be possible to turn it direct into a river or canal, but in most cases some purification would be required.

It should, therefore, be collected in open channels in the concrete floor of the laundry and let into a drainpipe of 6 in. diameter leading to settlement tanks. Coagulation of the soap into curd is an essential, and this could be done with chloride of lime or quicklime, with or without the addition of alum.

Settling tanks should allow for 12 hours' settlement, and the sludge would have to be disposed of by drying and burning, burying or whatsoever means could best be applied in the particular case.

7. Good road access is essential, and rail connection to the broad gauge system will probably also be necessary in most cases.

8. The actual types and numbers of the various machines to be installed in any laundry of this nature will depend entirely on the availability for quick delivery of the various patterns in commercial production. The output, as guaranteed by the makers, will have to be taken as a guide when the installation is planned, in order that no bottle-neck may be created in the various operations.

9. In certain cases water softening plant may have to be installed.

Apart from the saving in the consumption of soap laundry operations are greatly facilitated and expedited by the use of soft water.

Water softening apparatus are patented, and all that is necessary is to obtain one of the required capacity from an approved firm.

They are manufactured in a large range of sizes, and work on one or the other of two basic principles: either the removal (zeolytic exchange) by absorption, or by precipitation of the calcium or magnesium salts causing the hardness of the water.

In the Permutit system, the granular base exchange material termed "Permutit" has the property of giving up its sodium base in exchange for calcium or magnesium, irrespective of whether these are present in the form of carbonate or sulphate.

The Permutit is reconditioned by passing through it a weak

solution of common salt (NaCl), the absorbed calcium or magnesium combining with the chlorine and passing away in the form of chloride.

Reconditioning, or regeneration as it is termed, takes from **15** minutes to an hour, according to the type of Permutit used.

In the Royle system the reagents used are hydrate of lime for the carbonates and soda for the sulphates.

These are precipitated and ejected automatically, and the softened water is passed through a filter.

A reversal of the flow cleans the filter, and washes out the sludge. The loss of water is small, and the filtering material rarely requires renewal.

The Lassen-Hjort system uses in most cases a mixture of lime and soda ash as the reagent, and works on a carefully controlled proportioning of the reagent to the water to be treated.

The Kennicott system also uses lime and soda ash and works on a controlled proportioning of the reagent. It is also used in combination with a water heater—" the Kennicott combined heater and softener "—in which the steam passes through the water and raises it to boiling point, a convenience in a laundry, where large supplies of hot water are required.

10. A diagrammatic lay-out for a power laundry for 90,000 men is given on Pl. **117**.

CHAPTER XXX

WORKSHOPS

165. Principles governing the installation of repair shops in a theatre of war

1. The workshop system for the repair of equipment of the Army in peace is based essentially on the system of returning to a unit the identical articles sent into the shops, the unit making shift without them pending repair.

This system is not suitable for expansion in war.

2. In a theatre of war it is necessary to look far ahead: a system which may suffice for the first few weeks, or months, for a small expeditionary force may break down hopelessly when the strain of "provision" of equipment begins really to be felt, which will be when the immediate war reserves, stocked in peace, are exhausted. It will certainly be hopelessly inadequate when, as is almost inevitable, the original expeditionary force is heavily reinforced.

On disembarkation such local shops as are available may be, and will, in fact, have to be utilized for the repair work required in the first few weeks. But it is essential to resist the temptation gradually to expand such local shops to meet ever-increasing pressure. Sooner or later the limit of such expansion will be reached. An entire change of system then will cause a serious check in the steady work of repair, or, at best, will prove to be a most expensive undertaking.

In theatres of war where one port can be used as a temporary base while another one is being organized as a permanent base this difficulty will not occur, as existing shops can be used and expanded, if necessary, in the temporary base, while properly planned workshops are being constructed in the permanent base.

3. The problem in war is entirely different from that which arises under peace conditions.

In war it is essential to maintain the equipment of each unit up to full establishment in a serviceable condition. In general, if an article of equipment becomes damaged it must be replaced forthwith by a serviceable article; the unserviceable article being despatched to repair organizations. So fully was this principle adopted in the Great War that even boots for repair, and underclothing sent to laundries, reverted to the common stock, not to the original owner.

In order to lessen the strain on transportation and to reduce

reserve stocks, very minor repairs are executed *in situ* by unit artificers ; more extensive, but still minor repairs, are undertaken by mobile repair shops (usually part of corps organization). But the bulk of damaged equipment is sent down to the base, where it is sorted and classified as follows :—

i. Repairable.
ii. Break up for component parts.
iii. Scrap.

Scrap passes forthwith to R.A.O.C. salvage dumps as "produce." (i) and (ii) pass to repair workshops.

Repaired articles and spare parts obtained from breaking up are then transferred to the stores service, for issue as serviceable articles against indents.

4. The result of this system is that, in war, it should usually be possible to ensure that all sections of a shop are evenly loaded, and organized with a view to systematized production.

War repair shops are not in theory concerned with any pressure from users of equipment, but solely with the general flow of stores into the depots of the stores service, *i.e.* priority has to be given to repair of articles where provision is lagging behind demands from the front line.

The repair shops in fact should be regarded as a source of production.

5. Whilst there is no absolute necessity for the workshops of any particular service to be sited in or adjacent to the store depot area of that service it is a convenience for them to be close to each other, more especially when raw materials are drawn from and finished articles returned to the store depot ; means of transportation other than broad gauge can be installed between workshop and store with advantage, and thus reduce the demand for broad gauge rolling stock.

6. It is essential that all shops, however small at the start, should be planned both in lay-out and design for any possible future expansion. The whole future efficiency of the workshops will depend on this.

7. Whereas for efficiency and general convenience it is desirable for as many operations as possible to be conducted under one roof, military considerations, *e.g.* the vulnerability to air bombing of one large shop, may necessitate shops being broken up into comparatively small units, sufficiently far apart to ensure that a bomb hitting any one shop will effect no material damage to an adjacent one. A minimum distance of 50 ft. should be sufficient for this.

8. Whatever distribution and lay-out of shops is adopted, the same general principles must be observed, *viz.* a steady progress from one end to the other of the article to be repaired

or manufactured, with a minimum movement of raw material, coupled with a proper balance of the various sections in productive capacity, so that there are no bottle-necks between successive operations.

9. Whilst each service has its own special requirements to take into account, engineer considerations will demand the adoption of a standard design for all large workshops.

A clear span of 36 ft. has therefore been adopted as the standard for all workshops in the field, large workshops being 144 ft. wide made up of four 36 ft. spans, and smaller ones 108, 72 or 36 ft. as required.

A standard workshop building of this width has been designed, and working drawings and quantities have been prepared for it, and are sealed (*see* Appendix IV and Pl. **105**). The truss is identical with that for the standard store shed, except that the knee bracing is omitted. The eaves height is 22 ft. 7 in., to permit of overhead travellers being installed as required, and the stanchions are fitted with brackets to carry the necessary runways. Continuous roof lighting is provided in every bay. A 2-ton traveller will meet all normal requirements, and this capacity should not be exceeded, except where specified later. Shops in which it is certain that travellers will not be required are better kept low for the sake of warmth, and a maximum height of 15 ft. should not be exceeded. Standard store shedding is suitable in these cases (Pl. **23**). Where standard shedding is not available designs must be prepared to suit the materials available locally. A typical design in timber and corrugated iron is illustrated on Pl. **24**.

Floors of workshops should run through on the same level, and, except in cases specified later, should be of concrete, if possible.

Internal partitions should be reduced to a minimum, and, where necessary to segregate stores and tools, should be of expanded metal on easily moved supports.

10. Workshops in a theatre of war will comprise some or all of the following:—

i. R.A.S.C. workshops (Secs. **166** and **167**).—Base heavy repair workshops; retrieving shops for the repair and manufacture of M.T. spare parts, vehicle equipment and stores. In addition certain repairs are carried out in vehicle reception depots (Sec. **120**).

ii. Ordnance workshops (Secs. **168–170**).—Base and advanced base workshops. Line of communication recovery sections, which may function as line of communication workshops pending the establishment of stationary workshops; ammunition repair factories.

iii. Engineer workshops (Secs. **171–174**).—Repair workshops for the repair of engineering plant; manufacturing shops.

iv. Transportation workshops (Secs. **175** and **176**).—Where possible existing railway shops would be used and extended as required.

v. Mobile workshops are not considered in this volume, as any engineer work which might be required in connection with them would be confined to light temporary shedding, etc., and the normal camp structures.

11. The requirements of light and power will be very considerable for the various workshops in a base area. In general, machine tools, etc., will be motor driven, as the accurate fitting up of shafting and belting is a slow and cumbersome process, and not suited to buildings in a temporary form of construction. Electric supply from a central power house may, therefore, be the normal system in campaigns lasting more than one season (Chapter XXXI). It will, however, probably be necessary in some cases to retain as stand-by plant the oil engine generating sets originally installed in the workshops, in case the main power house is put out of action by enemy action.

12. **Internal workshop traffic.**—A general distribution system by tramway is usually unsatisfactory, especially where crossings over broad gauge lines have to be negotiated, and frequently involves double handling.

A tramway is most suitable for definite runs from one building to another one, *e.g.* manufacturing shop to store shed or stacking area.

The most satisfactory system is undoubtedly by hand, electric battery or motor driven barrows or trucks. This necessitates the provision of concrete floors, or at least runways, on the same level throughout the workshop area, but concrete can be laid rapidly by machinery, and will amply pay for itself in the long run. Such provision may also reduce the amount of road required in a workshop area, confining it (where it is required) to a road siding along a special loading shed and platform.

13. Special yard plant for handling heavy loads may also be required in particular cases.

This is considered specifically in the sections dealing with the workshop requirements of the various services and departments.

14. **Lighting.**—The lighting of workshops requires careful consideration. By day roof lighting is essential, and is provided by standard light fittings contained in a sheet of

corrugated iron, and fixed on each side of the ridge in every bay, as shown on Pl. **105.**

By night, general lighting of a workshop should be provided by a number of overhead reflectors with dispersive characteristic, each fitted with 200-watt lamps.

These should be spaced from 12 to 15 ft. apart and, depending on the roof construction, about 11 to 13 ft. above floor level.

This will give from 8 to 5 ft.-candles at 3 ft. above floor level, which may be considered as the working plane.

The smaller spacing should be given when considerable traffic among machines or materials on the ground is expected. When, however, clear spaces are probable, the greater spacing, *i.e.* less illumination, can be given.

The general lighting will be amplified by local lighting provided in fittings with jointed arms for 40 or 60-watt lamps for lighting up individual machines or benches where fine work is to be carried out.

Plugs for portable lamps, etc., should be provided liberally. A reasonable provision would be plug points at every alternate stanchion throughout each bay.

In the field a reduced scale may have to be given, additions being made as power and plant become available.

Where overhead travelling cranes prevent the even spacing of lighting units, fittings with suitable characteristics may be installed along the sides of the shop clear of the traveller.

As it will be quite impracticable to instal any system of blinds which will obscure the lights in the case of an air raid all lights in the workshops must be controlled by one master switch placed in a suitable central position.

15. **Heating.**—In order to obtain the maximum efficiency from workshops, in many climates some form of heating will have to be installed in the winter. The type ot construction of the buildings, their height and the nature of the operations performed make it almost impossible to instal any form of central heating which would function efficiently under active service conditions.

The only alternative is heating by stoves, industrial types of which are manufactured by several well-known firms. These should be installed in large workshops in cold or temperate climates on the scale of one 40,000 cu. ft. industrial heating stove per 2,000 ft. super of floor area in all shops except smiths' and similar shops.

Alternatively in tropical climates it may be necessary to improvise double roofs (Sec. **90**).

166. Heavy repair shops (M.T.), R.A.S.C.

1. The functions of a heavy repair shop (M.T.), R.A.S.C. are as follows :—

i. The overhaul and repair of all types of M.T. vehicles for which the Q.M.G's. branch is responsible, for which purpose it should be equipped and entirely self-contained.

ii. To a limited extent, and mainly in connection with vehicles passing through this shop, the salving and reconditioning of worn or damaged parts, and the manufacture of spare and replacement parts.

2. Repairs to M.T. vehicles are likely to be required at a very early date, and therefore a heavy repair shop, to be practicable and productive, must be in operation within 28 days of the arrival at the overseas selected base. It will be necessary therefore to effect such repairs as become necessary in existing or improvised workshops at the temporary base port (if any) until such time as the engineer work involved in the construction of this workshop at its permanent site can be completed.

3. **Site.**—Room is necessary for the parking of vehicles up to some 50 to 60 in number awaiting admission to the workshops, for which purpose a vehicle park of approximately 15,000 sq. ft. is required.

The total area required is approximately 430,000 sq. ft., and ample space should be allowed for expansion.

The site should be as level as possible, well drained, clear of obstructions and with good rail and road access.

4. **Lay-out.**—

i. In view of danger from enemy aircraft and the risk of fire, it is not advisable to place the whole of the shops under one roof, and separate buildings should, therefore, be provided, each to cover one or more sections.

ii. The shops should be conveniently situated in relation to the main stores and offices.

iii. The latrines, ablution places and similar adjuncts should be in positions convenient to the shops and offices.

5. **Accommodation.**—The following table gives the approximate areas of the shops, etc., which will be required for a workshop with a weekly output of approximately 30-lorry units of various types, *i.e.* sufficient to meet the demands for the expeditionary force in the early stages of a war under normal conditions :—

TABLE N.—SHOP AREAS, ETC., REQUIRED IN A HEAVY REPAIR SHOP (M.T.), R.A.S.C.

Workshop.	Ft. super.
(1)	(2)
Chassis test section	8,000
Erecting shop (chassis)	14,000
Assembly store	11,000
Stripping shop (chassis)	6,000
Unit erecting shop	19,000
Machine shop	9,000
Body repair and mounting shop	20,500
Coppersmiths'	8,000
Blacksmiths', foundry and pattern shop	13,000
Electricians', 5,000; Millwrights', 4,000	9,000
Body stripping and storage	5,000
Paint shop	5,000
Finished vehicle and final test	5,000
Offices	4,000
Stores	12,000
Total area	148,500

6. It is necessary to have some knowledge of the sequence of operations in order to obtain a suitable arrangement of the various shops :—

i. **Body and electrical stripping sections.**—Vehicles on entering the works for complete overhaul are taken to the body stripping section, where the body and the electrical equipment and instruments are removed. The electrical equipment and instruments are passed to the electricians' shop for reconditioning. The body is passed through the various sections of the body shop ; and the chassis, when divorced from its body, is passed to the chassis stripping section.

ii. **Chassis stripping and washing section.**—The chassis, on receipt in this section, is dismantled, the main units being removed in the following order :—engine, gear box, steering and chassis details, front axles and rear axles.

The stripped parts are passed through the washing tank, and then on to the view room tables in the next bay. The chassis frame, front axle and springs are passed to the blacksmiths' shop for viewing and reconditioning. The radiator tanks and various pipe lines are passed to the coppersmith's for necessary repairs.

iii. **View room unit assembly stores.**—Here the parts of the various units are viewed, and the required replacements demanded from store, or orders are passed for the repair of the unserviceable parts to the machine shop, etc. Whilst awaiting the arrival of these parts the units are stored on racks on trolleys, and, as the units are completed, the trolleys are pushed through to their respective unit erecting shops.

iv. **Unit erecting shops.**—Unit parts are received and erected in their respective assembly lines, *i.e.* engines, gear boxes, steering and chassis details, axles. On completion the units are passed to the chassis erecting shop.

v. **Chassis erecting shop.**—Frames and front axles are fed into this shop from the blacksmiths, as are also the requisite reconditioned parts from the coppersmiths. These chassis are gradually assembled as they are moved forwards towards the end of the shop, the frame first having its axles and wheels fitted, and then, as it is moved forward, the steering gear, chassis details, gear boxes and engine. At the top end of this bay the chassis being completed is then passed on to the chassis test section.

vi. **Chassis test section.**—Chassis are tested here ; light, and under full load. After washing and painting they are passed on to the body mounting shop, where the bodies are fixed on to them. Electrical equipment and instruments are fitted here, and the vehicle is passed to the finished vehicle section for final test, and thence to the vehicle reception depot (M.T.).

7. From this it will be seen that the main sequence of operations in the central block of buildings is: stripping, washing, viewing, assembling units, chassis erecting and chassis test.

Parallel to these shops are the body repair shops on one side, and the subsidiary shops such as coppersmiths and blacksmiths, on the other side. Any necessary expansion could be provided by extending shops longitudinally, or building additional shops in parallel line.

A typical lay-out, showing the direction of the flow of work is given on Pl. **106.**

8. **Design of buildings.**—The buildings will be normally of standard span and design as laid down in Sec. **165,** and 108 ft. wide.

The clear height and width of shop doors should be 14 ft. and 10 ft. respectively. Good lighting by day is essential,

and roof lights are necessary therefore in all shops wider than one span (36 ft.).

The floors in general should be hard and dustless, and preferably of concrete, and the foundations for machine tools must be solid.

9. The engineer requirements in particular shops are as follows :—

i. In the stripping shop, unit assembly shops and chassis erecting shops, overhead runways are of great assistance for conveying the units after assembly to the chassis erecting bays, and should be provided if possible. Water supply under pressure will be required for cleaning the chassis before stripping, after test, etc.

ii. Machine shop.—This should contain a tool room and tool smithy.

iii. Woodworking and paint shops.—A separate shop is required to permit of the spray painting of vehicles by means of either a non-lead or cellulose process.

Stores for paint, acid and other inflammables are required in this shop.

Special instructions regarding building precautions to be taken when paint spraying apparatus is used are given in Appendix XI.

iv. Foundry and pattern shop.—Good ventilation and good lighting are essential. Low pressure air, oil, gas, compressed air and hydraulic service are very desirable in these shops.

v. Electricians' shop.—This should be as free of dust as possible and be well lit and ventilated.

vi. Stores.—These should be situated conveniently to serve the various shop sections and provided with suitable fire-proof bins arranged in section as required. Suitable docks for loading and unloading at truck and lorry floor level should be provided in order to avoid unnecessary lifting. A gantry should be provided at one end to handle special heavy material which cannot be handled in the ordinary manner.

vii. Inspection pits are seldom used and should not be provided, but two hydraulic hoists in the finished vehicle section would be of great assistance.

viii. 2-ton overhead travelling cranes for lifting vehicle bodies "off" and "on" should be installed in each of the bays of the shops indicated on Pl. **106**.

10. Internal workshop traffic is best carried out with electric battery or petrol electric trucks of capacity up to 1 ton, of which 25 per cent. should be fitted with jib cranes capable of lifting the maximum single load, *i.e.* 10 cwt.; or failing these by tramway.

A runabout crane of capacity up to 4 tons will also be of considerable assistance. This should preferably be mounted on tracks.

11. **Heating and ventilation.**—If possible a heating and ventilating system should be installed. A constant change of air is required in the shops, and a special service in the foundry, smiths' shop, paint shops, acid cleaning sheds, etc. In some cases this can be combined with the heating arrangements, where these are required during the cold period of the year.

12. **Power requirements.**—Machines generally will be of the self-contained motor-driven type, and the total requirements of power and light will be approximately 100 kw. The normal source may be from a central power station with high voltage distribution to the workshop area; but in view of the importance of the work carried out in these shops it is desirable to instal stand-by plant.

This can be done most suitably by providing three 30–50 kw. sets. Two sets would take the normal load, and one set the lighting load only.

A small amount of D.C may be required at a later stage for welding, electric deposition, etc., and this can be provided either by a rotary converter or small independent D.C. set.

13. **Water supply.**—An efficient fire fighting service is necessary, and the shops should be ringed by a 4-in. main, with hydrants at frequent intervals. If necessary the pressure must be "boosted" up. Facilities for washing down vehicles are also needed, together with a concrete wash to take two vehicles at a time.

14. Camp accommodation will be required for 400 to 500 officers and men.

15. A list of the major items of material required for the construction of the workshops is given in Appendix X.

167. Retrieving installations

1. Although the base M.T. stores depot may be able to undertake certain retrieving of spare parts and other M.T. stores, and the heavy repair shop may also carry out a certain amount in the course of the repair and overhaul of vehicles, their capacity is strictly limited, and neither of these units can perform the duties of a retrieving installation without prejudice to their proper functions. As a campaign progresses

the quantity of part-worn and unserviceable stores is liable to appreciable increase, especially if accompanied by an increase in the numbers of M.T. vehicles in operation with the force. In such circumstances, having regard also to the general policy, and if local facilities are unavailable or unsuitable, it may become necessary to establish a separate and self-contained retrieving installation, as was done in several theatres in the Great War.

2. Briefly its functions would be :—

i. to receive unserviceable parts and stores—other than complete vehicles ;
ii. to recondition them or convert them to produce ;
iii. to manufacture parts and special fitments as required.

3. **Site and lay-out.**—The same considerations will apply as for a heavy repair shop (M.T.) R.A.S.C.

4. Although the actual sizes of the various shops will be dependent entirely on the conditions prevailing in the particular theatre of war, some or all of the shops in the following table will be required :—

TABLE O.—PROBABLE REQUIREMENTS FOR A RETRIEVING WORKSHOP

Shop or yard space	Percentage of total floor area required.
Reception, sorting and inspection section ...	4·25
Abeyance stores (for items awaiting repair)	4·25
Scrap yard	4·25
Cleaning shop	0·5
Stores : i. For new materials and parts drawn from stores depots ... ... ii. For new tools and appliances (held for issue to tool stores)	4·25
Tool stores, for daily issues	1·0
Tool room	1·25
Foundry	4·25
Smithy and welding shop	8·5
Fitting shop (with bench testing shop adjacent if complete engine overhauls are carried out)	21·25
Machine shop	10·25
Copper and tinsmiths' shop	16·25
Vulcanizing shop	1·0
Electrical shop	3·75
Woodworking shop	8·5
Paint and enamel shop...	1·0
Inspection section	3·5
Packing and dispatching section	1·0
Drawing office	0·5
General office	0·5

5. There is no general objection to the use of any suitable existing set of buildings, as the parts to be handled in the main

are small, and any expansion which might be required subsequently could conform or be of standard type.

Any such buildings should be single storied, measuring about 14 ft. to the eaves, with ample natural lighting, and provided with electric current for power and lighting, gas and water services.

If in new construction a standard type of shedding should be adopted, similar to that for a M.T. stores depot or heavy repair shop.

6. Special engineer requirements in the various shops are as follows :—

i. Cleaning shop.—This should be near the abeyance shop and will contain caustic soda, acid and electrolytic baths ; it should be provided with a light overhead runway for single heavy articles, and racks for light ones.

ii. Smithy.—An ash or clinker floor will suffice ; good roof ventilation is necessary.

iii. Machine shop.—A solid dustless floor is required, and the shop should be well lighted and heated.

iv. Coppersmiths' and tinsmiths' shop.—Should be provided with a gas service for brazing if at all possible.

v. Painting and enamelling shop.—A separate varnishing and spray painting room will be required, capable of being kept at a warm temperature. (*See also* Sec. **166**, 9, iii, and Appendix XI.)

7. Other engineer services such as power supply, water, road access, etc., will be on the lines already laid down for workshops in general.

168. Ordnance workshops.—General

Ordnance workshops in war may comprise the following :—

i. Stationary ordnance workshops ; either at the base or on the line of communication.

ii. Line of communication recovery sections.

iii. Mobile workshops.

iv. Ammunition repair factories.

Of these line of communication recovery sections and mobile workshops require little, if any, engineer work in connection with their installation, and are not considered any further in this chapter.

169. Stationary workshops

1. Stationary workshops will be located at the base, at the advanced base if any, and possibly elsewhere on the line of communication.

Their functions are briefly as follows :—

i. The repair of artillery equipment, mechanical transport and other ordnance stores.
ii. The manufacture of spare parts for guns, carriages, mechanical transport, etc., as may be necessary.
iii. The manufacture of stores of an experimental nature or non-service pattern, etc.

2. **Site.**—The site of a base ordnance workshop will usually be in or immediately adjacent to the base ordnance depot. It should be dry with good road and rail access, and capable of expansion by at least 100 per cent.

3. **Lay-out and accommodation.**—

i. The lay-out will depend on the number of workshop companies grouped together, but typical lay-outs for base and advanced ordnance workshops for an expeditionary force of 6 divisions are given in Ordnance Manual (War), 1931, Appendix VI, Pl. **4**, and Appendix VIII, Pl. **2**, respectively. These are repeated in Pls. **107** and **109** in this volume.

ii. This lay-out is based on a unit scheme of construction, and the order in which the shops should be erected is indicated on the plate.

iii. The total gross area of the workshop sheds is 491, 816 f.s., made up of the following :—

6 sheds,	each	395 ft.	by	144 ft.	nominal	(147 ft. overall).
2 ,,	,,	289 ,,	,,	144 ,,	,,	(147 ,, ,,).
2 ,,	,,	395 ,,	,,	72 ,,	,,	(74 ,, ,,).

Those trades which involve a fire risk or necessitate an uptake through the roof would be located in the 72-ft. wide sheds.

Where the site permits adjacent sheds may be joined together longitudinally, but in any but very level areas the necessity for the floor in any one shed to run through on the same level may make this impossible without excessive excavation.

iv. In addition to the main workshop buildings the following should be provided :—

(*a*) Instrument shop—289 ft. by 36 ft.
(*b*) Optical shop—76 ft. by 72 ft, (*See also* para. 8, below.)
(*c*) Electrical shop—199 ft. by 36 ft.
(*d*) Oil and paint store—about 1,000 f.s.

(*e*) Petrol store—about 1,200 f.s.
(*f*) Office buildings—about 5,500 f.s. (in one or more blocks as convenient).
(*g*) Small arms testing range.
(*h*) Two loading and unloading platforms—each 360 ft. by 30 ft. (*see* sub-para. vi, below).

v. The workshop offices should be sited centrally.

The latrines should be sited in places convenient to the offices and shops.

vi. As time and labour permit, loading and unloading platforms, as indicated above and raised to truck floor level, should be provided.

Suitable positions for these are given on Pl. **107**.

vii. A proper circuit and standing ground should be provided for in and out road transport, as well as ample parking space for vehicles awaiting repair.

For the lay-out on Pl. **107** some 340,000 f.s. of road surface would be required.

4. **Design of buildings.**—

i. The main sheds are 144 ft. (nominal) wide in four bays of 36-ft. clear span, each bay being provided with an overhead 2-ton travelling crane. The construction will be as far as possible of standard type as indicated in Sec. **165**.

ii. The floors must be hard and reasonably free from dust. Those in machine and fitters' shops, painters, etc., should be of concrete, if possible.

iii. Sliding or preferably shutter doors will be required at about 50-ft. intervals in long shops, and at the ends of each bay.

iv. Adequate day and artificial lighting is essential.

v. The smaller sheds are 72 ft. (nominal) wide in two bays each 36-ft. wide, with expanded metal partitions as required.

vi. Permanent foundations for machines will be restricted to power hammers, engines and precision grinders, until the situation has stabilized.

Even for lathes, planing and slotting machines, circular saws, etc., temporary timber foundations should be provided as a first measure.

5. **Internal workshop traffic.**—Six out of the eight 144-ft. wide sheds will be provided with overhead travelling cranes.

In addition 6- and 20-ton travelling gantries should be provided in the vicinity of the workshop sheds as indicated on Pl. **107**.

Electric or motor-power driven trucks up to 2-ton capacity will also be found useful.

6. **Power requirements.**—The machines generally will be of the self-contained motor driven type, and, where possible, current will be supplied from a central power house.

The equipment of ordnance workshops includes engines and generators necessary to enable the shops to start functioning: and these can remain as stand-by plant in case the central supply is interrupted.

Machine motors above ½ h.p. will be supplied at standard voltage, *viz.* A.C. 3 phase, 50 cycles at 400 volts between phases.

Smaller motors can be connected between the neutral and outer conductors at 230 volts, single phase, A.C.

As six of the eight main shops only will be fitted with overhead travellers the total number required is therefore 24.

The total connected power load installed will be approximately 700 kw., to which should be added a lighting load of some 50 kw.

Assuming a demand factor of 50 per cent. for power and 80 per cent. for light, electric power requirements will be approximately 390 kw.

7. **Water supply.**—An efficient fire fighting supply will be required; for this a 4-in. ring main should be taken between the 144-ft. and 72-ft. wide shops, and hydrants installed at frequent intervals.

8. **Instrument shops.**—A total area of 16,000 f.s. will be required for the lay-out included in Pl. **107.**

In the case of the **Optical shop** (Pl. **108**), it may be necessary, in order to avoid trouble from vibration, magnetic disturbance, and to secure an adequate field of view, to establish this shop separately from the main workshops, either at the base or advanced base. There must be an unobstructed view for at least 300 yards, but longer views are desirable.

9. **Accommodation of personnel.**—This has been included in the figures in Sec. **130,** 16. The personnel of the L. of C. recovery sections have not been included, however, as they will not require accommodation in this camp.

10. A list of the major items of engineer material required for the construction of these workshops is given in Appendix X.

170. Ammunition repair factories

1. Ammunition in considerable quantities becomes unserviceable through the usage to which it is subjected, and most of it can be repaired at a small cost. It is probable, therefore, that, in any but a very short campaign, repair

factories will be set up on similar lines to those erected in France in the Great War.

The time of provision and the scale of installation will be decided by higher authority.

2. **Site.**—An ammunition repair factory should be located where trucks returning from railhead can reach it conveniently, and where the transfer of repaired ammunition to depots presents no difficulties.

It should not, however, adjoin or form part of a depot.

The general requirements of the site are the same as for base ammunition depots.

3. **Lay-out and accommodation.**—The size of the repair factory will depend on the scale and nature of the operations. The lay-out, however, will be based on the following data, taken from a repair factory in France capable of repairing 300 tons a day, *i.e.* between 3 and 4 per cent. of the ammunition issued.

These are as follows :—

- i. The total area of the factory was about 1 square mile, which was fenced in.
- ii. The broad gauge system delivered the railway trucks to four receipt sheds, each 300 ft. by 30 ft., and 300 ft. apart, end to end, and traversed. In these the ammunition was sorted and classified for repair.
- iii. It was then moved by narrow gauge trucks to six sheds and dumping areas, each shed being 300 ft. by 30 ft., spaced 300 ft. apart and traversed. From these the ammunition was moved by narrow gauge trucks as required to the factory area.
- iv. The factory consisted of 12 brick and concrete sheds, each subdivided into 6 rooms, each 20 ft. by 12 ft., by solid walls, 2 ft. thick. Each shed was traversed externally and was 300 ft. clear of the neighbouring shed.
- v. After repair the ammunition was removed by the narrow gauge system to 3 issue sheds, each 300 ft. by 30 ft., which were served by the broad gauge system.
- vi. Other buildings were as follows :—
  - (*a*) Store sheds for components, materials, tools, etc.
  - (*b*) Small sheds, as required, for various purposes.
  - (*c*) Recovery plants, installations, etc.
  - (*d*) Office block.
  - (*e*) Power plant.
  - (*f*) Guard buildings.

vii. There was also a personnel camp for 14 officers and 300 O.Rs., and a labour camp for 1,500 men.

viii. An area, about half a mile from the factory and served by the tramway system, was provided as a demolition ground for disposal of unrepairable material.

4. The major items of engineer material required for the construction of a similar factory can be deduced from Appendix IX.

171. Engineer workshops—General

The Manual of Engineer Services (War) outlines the principles on which the repair of engineer plant will be organized in a theatre of war.

In addition to those for the repair of plant, workshops may be required for the manufacture of articles of new design, and for the conversion of raw material into standard stores.

Both classes of workshop should be sited in the area of an engineer stores depot, if possible.

Pl. **83**, which illustrates a typical lay-out for an ordnance or engineer store depot, indicates the area which would normally be set aside for workshops.

172. Repair workshops

1. The plant and equipment for an engineer repair workshop is necessarily limited to meeting the requirements of the force in the early stages of a campaign, and in many cases will require very considerable expansion. This expansion will be governed by the probable duration of the campaign and the conditions prevailing in the particular theatre of war.

2. **Lay-out.**—The lay-out must, therefore, permit of large expansion of individual shops, and an ample area must be set aside adjacent to them as a reception and sorting area for plant, etc., requiring repair.

3. As a guide to the development which is likely to take place within a few months of the start of the campaign the following table based on experience in the Great War gives the floor areas of the various shops which may be required.

A list of the plant and machinery for these shops is given in Appendix XV.

TABLE P.—SHOP AREAS, ETC., REQUIRED IN A REPAIR WORKSHOP

Shop.	Area f.s.	Remarks.
(1)	(2)	(3)
Machine shop	18,300	No. 1 Shop Area, 23,500 f.s.
Maintenance shop	3,700	
Electricians' shop	1,500	
Foundry	3,500	No. 2 Shop Area, 14,000 f.s.
Metallurgical shop	1,500	
Plumbers' shop	4,000	
Smiths' shop (including welding)...	5,000	
Carpenters' shop	9,000	No. 3 Shop Area, 22,000 f.s.
Pattern shop and store	1,500	
Saw-mill	9,000	
Painters' shop	2,500	
Power house	2,000	A saw-mill may also be installed in timber yard of store depot.
Stores department	9,500	
Offices (incl. Head office 2,000 f.s.; Production department, 2,000 f.s.; Drawing office 2,300 f.s.; Inspection 2,000 f.s.; Workshops department 1,000 f.s.	9,300	
Miscellaneous	700	Police, time clocks, etc.
Total area of buildings ...	81,000	

4. **Construction.**—Engineer shops, similarly to M.T. and ordnance workshops, will be as far as possible of standard design and construction, as already described.

The normal width will be 108 ft. in three spans of 36 ft., and one bay of each shop will be fitted with an overhead, travelling crane of 2-ton capacity.

Shops involving a fire risk should be segregated together.

The floors should run through on the same level and be as hard and as dustless as possible; concrete floors should be provided if possible, in pattern makers', fitters' and turners', painters' and electricians' shops.

Good day and artificial lighting is essential.

5. **Internal workshop traffic.**—As time and labour permit, a loading and unloading platform 800 ft. by 30 ft. should be provided, served by a broad gauge railway, from which plant, etc., can be moved to the shops either by narrow gauge trucks, or preferably by hand, electric or motor driven trucks, for which runways or roads will have to be provided.

A light runabout crane will be a useful adjunct.

A light overhead hand travelling crane in the machine and assembly shops, and a travelling gantry in the yard outside the shops, would also be useful.

The workshops should also be provided with a second platform at lorry floor level for possible service by road vehicles.

6. **Power requirements.**—Tools and plant will be of the self-contained motor driven type, and, where possible, power will be taken from a central power house. Pending such an arrangement, and for subsequent use as stand-by plant in case of interruption in the main supply, a small power house should be installed in the workshops, and should be sited clear of any possible future extensions.

If a manufacturing shop is installed as well as repair workshops, the power house should be in a position convenient to both.

The total power and lighting load may be put at some 300 kw.

7. **Water supply.**—An adequate fire fighting system will be required for the carpenters', painters' and similar shops, which should be ringed by a 4-in. main with hydrants at frequent intervals.

8. **Personnel camp.**—A camp for 10 officers and 240 O.Rs. will be required. These should be in the immediate vicinity of the workshops, and can often be suitably combined with the camp for the store depot personnel.

9. A list of the major items of engineer material required for the construction of these shops is given in Appendix X, and a typical lay-out on Pl. **110**.

173. Manufacturing shops

1. Manufacturing shops may be required for two purposes :—

i. The conversion of raw material, especially timber, into comparatively bulky articles, with the object of economizing sea freight.

ii. The production of a first supply of articles of new design until such time as supplies can be received from home.

The latter function is often best carried out in repair workshops, which must in consequence be planned with this possibility in mind.

2. In most cases it will be necessary to construct and equip a manufacturing shop for the conversion of timber into manufactured wood ware, as it will be found more satisfactory and more conducive to a good output to concentrate such work in a special workshop than to allow it to remain as one of the functions of a repair organization.

The establishment of such a shop, the types of articles to be manufactured and the output to be attained will depend entirely on the theatre of war and the nature and duration of the operations.

3. Whatever may be the article manufactured, however, certain principles must be observed if the output is to be regular and economic.

These are as follows :—

i. The flow of material must be continuous through the various processes of manufacture.

ii. Manhandling of material, either raw or in the various stages of manufacture, must be reduced to a minimum.

iii. The lay-out must allow for expansion, as may be required, which expansion must necessarily be in the form of adding complete manufacturing units to the workshops.

iv. A balance must be secured between the various sections in productive capacity, so that there are no bottle-necks between successive operations : each part of the finished article must be fed in at the right point and in the right quantity with the minimum of wasteful movement.

v. There must be quick evacuation of manufactured products from the workshop to the store depot.

4. A typical lay-out for any form of manufacturing workshop will therefore be on the following lines :—

i. Raw delivery siding.

ii. Raw material dump, store, or stacking area ; with space for at least a 48 hours' supply of material.

iii. Manufacturing area arranged in depth in a series of units, so that the manufacturing process is continuous through each unit.

iv. Manufactured articles store or stacking area ; with space for a 48-hour output.

v. Departure siding.

Expansion would be carried out by lengthening the sidings, if necessary, and adding on manufacturing units laterally as required.

5. Mechanical means of transport will be required between sidings through each manufacturing unit. These may be by a tramway system, conveyors or whatever system is the most convenient and labour saving in the particular case.

In certain cases it may be found advantageous to have a tramway between the manufacturing shop and the store depot ; more especially when one particular article is being made and a direct run can be arranged from the stacking area in the store depot to the workshop and back again.

This will save considerably in demands on broad gauge rolling stock, and should permit of a considerable reduction

in the sizes of the raw material and manufactured article stacking areas in the workshop.

6. An illustration of manufacturing shops in the Great War is given in Sec. **174**.

174. Woodworking shops at Les Attaques (Pl. 111)

1. These woodworking shops were established for the conversion of about 300 tons of timber daily into trench stores for the equivalent of 30 divisions. Experience proved that it was economical thus to concentrate in one area the whole of the woodworking machinery, except that for heavy bridging timber.

2. The whole lay-out and organization of the workshops were designed to pass the material from the raw timber through its successive stages to the finished article with the minimum amount of handling.

The raw timber was graded for length, width and thickness : if this was not done in the first instance it was found that waste or extravagant use of labour resulted, as the timber had then to be drawn from stack, sorted, the suitable pieces selected and the remainder returned to stack.

The same principle was reflected in the location of the stacking ground for manufactured articles close to the mills so that no movement other than by decauville was necessary prior to final despatch by railway.

3. The lay-out and sequence of operations was as follows :—

- i. Railway line for off-loading only.
- ii. Raw material stacking ground.
- iii. Stacking space for immediate supply to the mill.
- iv. The mill.
- v. Stacking space for cut material.
- vi. Nailing sheds (employing 250 nailers).
- vii. Stacking space for finished articles.
- viii. Decauville for removal of finished articles to the group area.
- ix. Group area for manufactured articles (to hold 10 days' output).
- x. Railway line for loading for despatch only.

A clear definition of responsibility was found to be essential. In area ii. the workshops staff checked in the raw material, giving a receipt to the store depot representative : in area vii. the manufactured articles were handed over and a receipt obtained from the stores representative.

All movement outside these limits was entirely under the control of the store depot staff. Each stack, whether raw

material or manufactured articles, was surrounded by decauville, the traffic on which was organized to circulate in one direction only, in order to avoid congestion and delay.

4. The principal machinery installed was as follows .—

Group A. 4 pendulum saws, 3 42-in. circular saws, 1 planer.

„ B. 3 mills, each 6 26–30-in. circular saws and 1 pendulum saw.

„ C. 3 mills, each 6 26–30-in. circular saws and 1 bandsaw.

„ D. 1 vertical log band saw with travelling carriage.

„ E. A special mill with a joiners' shop, in which all samples were made for approval before being passed to the other mills for repetition work. 7 18–26-in. circular saws, 3 bandsaws, 2 planers, general joiner, thicknessing, morticing and picket sharpening machines.

„ F. A saw doctor's shop with 3 saw-sharpening and 3 gulleting machines, brazing tables, emery wheels, etc.

5. The large mill (A) was served by a 70 h.p. steam engine : the smaller mills (B and C) were calculated at 5 h.p. per saw on account of the diversity factor in the load and driven by steam engines burning scrap wood, sawdust, shavings and 5 per cent. of coal : the total h.p. installed was 284 (154 steam, 130 in D.C. and A.C. motors).

6. 3 officers, 422 artisans and 387 unskilled labourers were employed.

175. Transportation workshops

1. Transportation workshops may be required for railways, docks and inland water transport. Suitability of site may require separate workshops for each of these services.

Manufacturing work for all transportation services will normally be carried out in the railway workshops, which will therefore fulfil the functions of the main transportation workshops. Small local workshops, using the standard 36-ft. span buildings, to suit the special conditions of the particular campaign may be required for docks and inland water transport.

Full use will be made of any existing railway workshops in a theatre of war, but these are unlikely to be found on the scale required to cope with the intensive railway activity necessitated by the demands of active service of any magnitude.

2. **Site.**—The site for the railway workshops will be governed principally by its suitability for construction of the

workshops and of the railway yards and sidings connected with them, with ample room for possible future expansion. This premises a level site of 40 to 45 acres, situated suitably for railway traffic working; and it is a convenience if the railway stores depot is near to the railway workshops.

3. The extent of the railway workshops will not vary directly with the size of the force, but will be mainly determined by the extent and nature of the line of communication and the existing resources of the railways in the theatre of war.

4. **Lay-out.**—A type lay-out for a railway workshop is given in Pl. **112.** This is suitable for a force of 6 divisions with a line of communication up to 150 miles in a theatre of war where the existing railway workshops are not capable of expansion.

5. **Accommodation.**—The following table gives the approximate sizes of the shops which will be required.

TABLE Q.—SIZES OF SHOPS REQUIRED IN A TRANSPORTATION WORKSHOP.

Description of shop.	Length.	Span.	Remarks.
(1)	(2)	(3)	(4)
Erecting and repair shop ...	240 ft.	52 ft.	2 35-ton overhead electric travelling cranes. Span would require to be 60 ft. for Indian broad gauge (5 ft. 6 in.)
Boiler shop	120 ft.	52 ft.	
Machine and fitting shop * ...	240 ft.	72 ft.	Buildings to be arranged for main and counter shafting. * Equipped with 2-ton overhead traveller.
Wagon repair and wagon wheel shop *	130 ft.	36 ft.	
Saw-mill and carpenters' shop	170 ft.	36 ft.	
Locomotive wheel shop ...	80 ft.	36 ft.	3½-ton overhead traveller.
Smith's shop	100 ft.	36 ft.	
Whitemetal shop	40 ft.	36 ft.	
Wagon repair shed	200 ft.	36 ft.	
Welding shop	20 ft.	36 ft.	
Foundry	100 ft.	36 ft.	2-ton overhead traveller.
Power house sub-station ...	100 ft.	72 ft.	
Workshops detail stores, locomotive spare part stores and office (2 officers, 2 clerks) ...	230 ft.	72 ft.	—
Wagon detail stores and spare part stores	100 ft.	72 ft.	—

6. In addition to general workshop buildings a main office and drawing office approximately 2,500 f.s. will be required for 4 officers, 12 clerks and 10 draughtsmen. This office should have road access.

Latrines and ablution places should be provided near :—

the main office;
the erecting shop;
the machine and fitting shop; and
the wagon repair depot.

The personnel may be taken as 250 O.Rs. and 300 civilian labour, approximately equally distributed amongst the three latter latrines proposed.

Foremen's offices and sub-stores will be required.

7. **Design of buildings.**—With the exception of the erecting shop and boiler shop, the railway workshops will be constructed of standard 36-ft. spans. The larger shops being 72 ft. wide are built up of two 36-ft. spans. In this latter case roof lighting is required.

The shops requiring overhead travellers and provision for shafting have been detailed in para. 5, above.

8. **The erecting shop and boiler shop** must be capable of spanning three tracks. This requires a minimum of 52-ft. span for standard gauge and 60-ft. span for Indian broad gauge (5 ft. 6 in). These shops have to carry two 35-ton overhead electric travelling cranes. A suitable typical cross section is given on Pl. **112.**

Two inspection pits are required throughout the length of the erecting and repair shops, as shown on Pl. **112,** and six pits approximately 6 ft. long by 4 ft. wide by 3 ft. deep to suit actual types of boilers will be required in the boiler shop. All these pits should be drained.

9. **Electric power and light** will be required throughout—maximum total load approximately 320 kw., average load 250 kw.

10. **Water supply requirements** may be divided into three categories :—

i. Drinking water and small supplies required in all shops.
ii. Water supply to locomotives and cranes in the yard—a 6-in. water column outside the erecting shop, in the wagon yard and at suitable places on the shunting neck.
iii. Fire fighting supply for :—
Stores, carpenters' shop, saw-mill, wagon repair shop, wagon repair shed and wagon repair yard.

11. **Air pressure mains.**—A 3-in. main distribution with $1\frac{1}{2}$-in. and $\frac{3}{4}$-in. branch pipes for air at 100 lb. per sq. in.

pressure will be required to every second column in the boiler shop, erecting shop and fitting shop, and two supply points in all other shops and the power house.

12. Foundry coke and smiths' coal can be delivered by wagon as required from R.A.S.C. Bins are required outside the shops concerned to hold one and a half wagon loads.

13. It is desirable that the whole railway workshops area should be fenced in with 6-ft. fence of single stranded barbed wire, with strands 9 in. apart.

14. **Internal workshop traffic.**—The majority of the traffic in and out of the workshops will be by rail, so that road access is only necessary to the main offices. Internal pathways with a hard smooth surface will be required as shown on Pl. **112**, to allow the internal transport of material by power driven trollies. The minimum width should be 8 ft., with 12 ft. crossing places every 100 ft.

15. **Personnel camp.**—To begin with, a personnel camp for 6 officers and 250 O.Rs. will be required, and a labour camp for 300 civilian labourers, but this requirement will probably be rapidly increased as the campaign progresses.

16. Special plant, such as locomotive steam yard cranes, etc., will be supplied by the transportation directorate.

176. Locomotive running sheds

1. A running shed for locomotives will be required at the beginning of approximately every 100 miles of line of communication and at the last engine changing station.

2. A suitable shed for standard gauge could be constructed from two standard 36-ft. spans, giving a covered area of 72 ft. by 220 ft. This would accommodate four tracks, two in each bay, and each track would hold four normal locomotives. A minimum head-room of 20 ft. above rail level is required. For Indian broad gauge a minimum of two 42-ft. spans would be required.

3. The sheds should be arranged with ridge and eaves ventilation and must be fitted with two continuous smoke troughs in each span (one over each track—15-ft. centres for standard gauge) with suitable uptakes at intervals.

4. A lean-to annexe for a shed office, small store and repair shop, 15 ft. by 100 ft. should be provided.

5. Roof lighting is not practicable, and therefore the maximum possible lighting by ample side windows is necessary.

6. Electric power and light (approximately 10 kw. maximum load) is desirable.

7. A water supply is required for filling locomotive tenders and for washing out, at approximately 60,000 gals. a day. Local storage tanks of a minimum of 30,000 gals. capacity with a head of 30 ft. are desirable.

8. Each track in the shed requires an inspection pit throughout the full length, and additional pits will be required in the yard—depth of pit 2 ft. 6 in. (to foot of rail). The pits must be very efficiently drained, as anything from 2,000 to 3,000 gals. of water is used for washing out an engine, and this quantity may be emptied into the pits from one engine alone in less than 10 minutes.

9. Latrines and ablution places for 50 O.Rs. and 50 civilian labourers are required at locomotive sheds, and a personnel camp near by for 250 O.Rs. and 150 civilian labourers.

CHAPTER XXXI

POWER AND WATER INSTALLATIONS

177. Electric power installations

Whereas in peace the principal consideration which governs the design of an electric power installation is economy of operation, in war more important considerations will be :—

i. Weight of units, which will affect transport and speed of erection.

ii. Ease of operation.

iii. Standardization of units, which will affect quick supply and easy replacement of parts.

iv. Local fuel resources, which may affect the type of plant installed.

v. Silent running and clear exhaust.

vi. Vulnerability to air attack.

The Text-books of Electrical and Mechanical Engineering gives all the necessary details of the installation of electric supply systems and of the operation of power stations.

178. Base installations

1.—i. Foresight and energy will be required from the outset of a campaign in order to prevent the creation at a base of a system of power supply from a heterogeneous collection of prime movers, some D.C., some A.C., of different voltages and even of different frequencies. In a temporary base it may not be possible to organize for an army before it is actually occupied, and temporary expedients cannot therefore be avoided. Some more or less reliable local supply, if available, must inevitably be taken into use.

ii. As the occupation of a temporary base will usually be limited to the period required to prepare the permanent base (F.S.R., Vol. I, 1930, Sec. **89**), there should be no great difficulty in lighting temporary depots (which in this case may be in, or at least near, the dock area) and temporary workshops (which may be in existing buildings in the town area) by extensions from an existing system.

iii. Outlying personnel camps, hospitals, etc., may present difficulty if unduly scattered, and it may be advisable as a temporary measure to put in small isolated generating sets, making use of whatever plant may be available or procurable locally.

iv. In the meantime plans should be prepared for a considered scheme for the supply of the current required at the permanent base (whether in a new area, or a development of the original port of landing) for power and lighting purposes, which can readily be expanded at will to meet future extensions of the base.

2. The supply of electricity in a base area can be considered under two main heads :—

By extensions of an existing system.

By a complete new installation.

i. **Extensions of an existing system.**—(*a*) Most developed countries have extensive electrical distribution systems, of which the utmost use should be made to save the time and expense of installation, and the expense of man power in the operation of a new installation. If necessary, additional generating plant may be installed in existing power stations, if the existing distribution system is large enough to convey the power so generated to the extensions required for military purposes.

(*b*) Even if extensions to existing systems are not practicable to outlying areas the fullest use should be made of them in town and dock areas, where the installation of another distribution network would be a very lengthy and costly process.

(*c*) Transformers, motors and other machinery added to existing systems must be of the correct voltage and frequency.

(*d*) Some services may be equipped with machinery driven by 110-volt D.C. motors. If only two or three motors are involved, it is better to replace them by A.C. motors. Otherwise A.C. to D.C. converting plant will be necessary.

(*e*) As the power station may be put out of action by air attack, it may be desirable, as circumstances permit, to erect another power station, some distance away and in a suitable position for connection to the distributing network, as a stand-by.

ii. **Complete new installation.**—The scheme for this will be affected by the following considerations :—

(*a*) The rise in demand for current may be very rapid: therefore generating plant should be demanded which can be obtained at short notice, and is in units in general commercial production, and of a size which can be transported readily to the site and erected rapidly. This can be put at about 250 kw. for a single unit.

Although engines up to this size can probably be obtained at short notice by taking those in course of erection at makers' works, the alternators are not so

likely to be available, and may have to be made specially, which would entail a delay of three months or so.

If, however, it is decided to instal steam sets, say in order to utilize fuel available locally, a turbine of 1,000 kw. may be as easy to instal as one of 500 kw.

Turbine sets are manufactured with auxiliaries such as condensers, etc., which are mounted on a self-contained base, and which require therefore a minimum of constructional work for their installation. Such a type is often most suitable to meet the requirements of a rapidly constructed base. "Self-contained" boilers also are available, which do away with the necessity of brickwork for settings.

More often the prime mover would be of the heavy oil solid injection type, and the generator standard A.C. 3-phase, 50 cycles. The generating voltage will depend upon circumstances. If the greater part of the load is within say a ¼-mile radius of the generating station, it will be better to generate at 400 volts, and to use step up transformers to transmit at higher voltages to outlying areas. Generally, however, in large bases it will be best to generate directly at 3,300 volts, stepping up to a higher voltage as required for transmission.

(*b*) Although one large power station may be put out of action by a single bomb, under active service conditions the difficulty of running two independent stations in parallel, especially through transformers, makes it advisable to concentrate all the plant required in one station.

(*c*) The site selected should be near an existing railway and water supply, and should preferably be near the load centre; otherwise distribution losses may be heavy, and voltages may vary greatly at the far end of the system; it should not, however, be in such a position that aircraft bombing other targets will be likely to hit the power station by mistake.

3. A typical system will be, therefore, on the following lines :—

i. A power house sited near road, rail and water, and probably—though not essentially—near the load centre of the base area; equipped with unit sets of a maximum capacity of 500 kw., or, where the total load is not too large, preferably with handier sets of capacity between 150 and 250 kw.

The number and size of the sets to be installed will depend on the total requirements, but the number of sets installed in any power station should not for general convenience of working exceed six (not including spare plant).

The plant installed should be sufficient to take the maximum peak load, which itself can be assessed at not more than 60 per cent. of the total connected load, together with 20 to 25 per cent. spare plant.

ii. A stand-by power station, at least half a mile away, but sited so that it can be connected readily to the distribution network, and equipped with 40 to 50 per cent. of the plant in the main power station.

iii. A H.V. connecting feeder between the two stations.

iv. A H.V. distribution system at 3,300 or 6,600 volts, 3 phase, 50 cycles (6,600 volts is sufficiently high for a 6 to 12-mile radius) radiating from the power station to transformers sited at convenient points in the various areas. The number of transformers and of separate circuits must depend on the size and lay-out of the base; but, in order to economize in the low voltage transmission, it may be found advisable to limit the load on lighting transformers to 10 kw. in some cases.

The circuits should be balanced as far as possible. The ends of the H.V. distributors may be brought together, when opportunity offers, and as the system develops, in order to realize the advantages of a ring main, and this possibility should not be lost sight of when the H.V. distribution system is laid out in the first instance.

Owing to the frequent changes in personnel which are bound to occur "simplicity" must be the keynote of the design and lay-out of the system.

All distribution will be therefore by overhead lines, which are easily repaired if damaged by bombing.

4. **Safety precautions.**—In purely military areas on active service it may not be necessary to comply with the legal regulations prescribed by the local and national authorities, but it will seldom be practicable to instal a distribution system in a base area in a well developed country which does not cross roads, railways and telephone wires; and the extent to which such regulations may be disregarded must therefore be left to the discretion of the technical staff on the spot.

In no circumstances, however, should uninsulated H.V. lines be less than 20 ft., or L.V. lines less than 17 ft. from the ground.

Wires must be insulated when they are within the following distances of buildings or trees :—

8 ft. for H.V.

6 ft. for L.V.

No building operations or dumps should be allowed to take place or be formed under overhead lines, particularly H.V.

5. A diagrammatic lay-out of a hypothetical base area spread over some 50 square miles is given on Pl. **118**, illustrating an electric power installation on the above lines, and a list of the engineer stores required for the H.V. distribution is given in Appendix XVI.

In a base concentrated in a smaller area, as a rough approximation, requirements can be reduced in proportion to the decrease in area.

6. A typical lay-out of a main power station, installed in a 36-ft. standard workshop building is given on Pl. **119**.

179. Water supply installations

1. This section should be read in conjunction with Military Engineering, Vol. VI (Water Supply), which deals with the various problems which may occur in the field in the supply of water to the troops, and which also gives details of a typical scheme for the supply and distribution of water to a large permanent camp for 10,000 men.

2. In a theatre of war at the permanent base, and possibly at an advanced base, there will usually be far larger numbers than these to provide for, and this section therefore analyses the conditions under which a comprehensive scheme for supply might be envisaged, and the lines on which it would be worked out.

3. In the permanent base area, particularly if there is any considerable concentration of hospitals, convalescent depots, etc., in the area, the numbers to be catered for may be in the region of 50,000 or more, and the consumption in various workshop and manufacturing activities may also be very large.

Whether the supply for these numbers would be from one general source or from several will depend on a variety of conditions, of which two perhaps are outstanding :—

i. The available or potential sources of supply.

ii. Whether, other things being equal, the probable duration of the campaign will justify the initial expenditure involved in a large and comprehensive distribution system.

4. The longer the duration of the campaign the more will such a system be justified and even necessary, particularly in

view of the large numbers of personnel required to look after a multitude of small plants.

As an extreme case in the Great War, Salonica can be instanced, where the supply for the base area was obtained from :—

i. a series of artesian wells supplying the local water company ;
ii. three old Roman aqueducts supplying the upper parts of the town ;
iii. over 100 deep wells, which had to be sunk by the Army.

Here, however, there was no possible single source which could have been developed to give the necessary supplies.

5. In the early stages of development of the permanent base, it will probably be necessary to instal temporary supplies to individual areas.

Some may be provided by extensions from a local system, especially if in the vicinity of a town ; but it must be borne in mind that few countries are as well developed as regards water supply, and more particularly water distribution, as the United Kingdom, and that in the vast majority of cases any local water supply authority there is will probably have little reserve to meet even a portion of the demands which an occupying army would make on it. As a further illustration it may be mentioned that the daily supply for Constantinople in 1919 from the local water company was less than 1 gal. a day per head of population.

6. Sources of water and their development are considered in Military Engineering, Vol. VI. It is seldom that any well supply could be developed to such an extent as to make it a centralized source of supply for the whole base area, and to obtain this either lakes, rivers, or canals must be available. There are few fresh water lakes close to the sea, and rivers or canals therefore are usually the only potential sources for a concentrated supply.

In some cases dams will be required to store up sufficient water through dry seasons, in others there will always be sufficient water in the rivers. If dams are necessary it is very doubtful if it will be worth attempting to centralize supply, as the construction of a dam is a slow business, and may be difficult in many cases.

Centralized water supply systems are usually only possible, therefore, when there is a stream or canal within reasonable distance of the base area, and with a sufficient daily flow **all the year round** to meet requirements.

The exceptional cases will be when there are hills or mountains near the base area, where it may be possible to find large springs, lakes, etc., or to dam up a series of mountain

streams, and to connect the reservoirs thus formed into one supply system.

The most difficult case is when water must be taken from a river or canal. The water will always be muddy, and will require settlement, filtration and purification before it can be distributed for consumption.

Furthermore, rivers are usually brackish near their mouths, and it may be necessary to have the intake some distance upstream.

In any case analyses of water proposed for consumption should always be made as a guide to purification methods to be adopted.

7. **Intake.**—The digging of a special sump in a river or canal bank in which to place the water intake of the pumps is always unsatisfactory, as these sumps accumulate an excessive quantity of mud and dirt. Wherever possible it is far better to build out light framework into the river or canal to carry the suction pipes.

If necessary it will have to be piled, and it must be carried far enough out to be beyond the seasonal variation of flow in the river (if any). Modifications to this may have to be made so as not to interfere with any navigation there may be on the river or canal.

Two pumps should be installed, each capable of pumping the daily requirements of water in 8 to 10 hours, one pump acting as a stand-by.

If serious danger from enemy aircraft is to be anticipated, it may be desirable to put the pumps in separate pump houses not less than 300 ft. apart.

The pumps can be operated electrically or by any convenient form of prime mover. If electrically operated they will frequently help in levelling out the load on a power station, as they can be worked at any time in the day or night.

8. **Sedimentation.**—Pumping will be to a series of settling tanks, preferably in close vicinity to the intake. A very large amount of sludge has to be cleared from these tanks; in the case of muddy waters like the rivers Tigris and Euphrates, it may amount to 20 to 25 per cent. of the total taken in. It is a convenience, therefore, if the settlement tanks can be raised off the ground. Sectional pressed steel tanks on a series of low concrete pillars or dwarf walls can be easily erected in any sizes as required, whereas reservoirs dug in the ground may require lining with concrete, waterproofing, etc., and take much longer to construct.

It will usually be necessary to expedite natural settlement with alum in order to reduce the sedimentation period, and hence the capacity of the settlement tanks.

It may also be desirable, in order to reduce this period still further, to introduce a filtration process (usually rapid sand).

These processes are described fully in Military Engineering, Vol. VI.

Generally an 8- to 10-hour capacity will be required in the settlement tanks, which should be divided into two independent sections.

9. **Purification.**—Chlorination, either by Paterson Chloronome or a similar installation, or, failing an automatic system, by improvised field methods, will always be necessary. (*See* Military Engineering, Vol VI.)

10. **Main pumping station.**—The pumps installed should be of sufficient capacity to deliver the supplies required against the calculated head in a 16-hour maximum day, with 25 per cent. stand-by plant. If the pumps are liable to enemy bombing 100 per cent. stand-by plant should be installed in an adjacent pump-house.

The pure water tank or reservoir should hold at least a 2-hour supply for the pumps.

11. **Distribution.**—

i. While the actual system of distribution must depend on the topographical features, as a base area will usually be more or less flat (this is necessary for transportation purposes), the indirect system will be the method of most general application.

ii. The general scheme of distribution will be, therefore, by ring main feeding a series of reservoirs, one in each sub-area of the base. These reservoirs will be either pressed steel sectional tanks on a steel or brick structure, raised sufficiently high to give the necessary pressure through the area served, or reservoirs or tanks on hills, etc., of the necessary height.

The reservoir capacity should be not less than 1 day's supply for the sub-area served.

iii. Alternatively, if the whole base area is approximately level, the direct—indirect system might be adopted, and the raised tanks made use of to serve as a series of equalizing reservoirs through the system.

iv. At one or more points in the system (cross) riders should be laid so as to provide alternative lines of supply in case of casualties to the mains.

v. Each sub-area should also be connected up on a subsidiary ring.

vi. After the requirements for each sub-area have been determined, all the necessary calculations for the sizes of pipes required, etc., can be made as described in Vol. VI.

12. **Fire supply.**—It will seldom be possible to raise storage reservoirs sufficiently high to give the pressure required at fire hydrants (80 lb. per sq. in.), and booster pumps will usually therefore be required in those depots, etc., where fire mains have to be installed.

13. **Water supply for animals.**—Chlorinated water is not required for animals, and it may often be possible to develop a small local supply for watering the animals of remount depots and veterinary hospitals, and thus reduce appreciably the demands on the main supply.

This can sometimes be done by siting these units near the main source (river or canal), and either pumping direct with a small independent pump, or supplying from the main pumping station (if reasonably near) direct from the settlement tanks, and omitting the chlorination stage.

14. A typical installation is worked out on the diagrammatic plan of a base area (Pl. **120**) as an illustration of what might be done in a base area should conditions justify it, and an approximate list of water supply plant and stores is given in Appendix XVII for this installation. This list does not include the stores required for any of the sub-area distribution systems. Where the base is concentrated in a smaller area, as a rough approximation these quantities may be reduced proportionately.

PART VI.—MISCELLANEOUS ENGINEER WORK ON ACTIVE SERVICE

CHAPTER XXXII

ENGINEER WORK IN CONNECTION WITH THE FORMATION OF AN OVERSEAS BASE

Note.—In this chapter the following definitions have been observed :—

A **wharf** is a landing place or platform built out into the water for the berthing of vessels.

Where parallel to the shore it is called a **quay.**

Where perpendicular or oblique to the shore it is called a **pier.**

A **jetty** is a wharf parallel to the shore, but built out from it, and connected to it by gangways.

180. General considerations

1. F.S.R. Vol. I, 1930, Sec. 89, lays down that an army operating overseas will normally require the development of at least one port in the theatre of war as a base for the maximum force which can be maintained from that base: and that a temporary lay-out, distinct from the lay-out for permanent maintenance, will be required for immediate use. It may be possible to use a separate port for temporary maintenance, but if, as is more likely, no alternative port is available for this purpose, sites must be set aside for temporary maintenance purposes which will interfere as little as possible with the development of the permanent base organization.

In this connection a glance at the various campaigns fought in the Great War is instructive.

In only two of these campaigns were there ports sufficiently developed for immediate use, viz. France and Egypt. In two others, Salonika and German East Africa, not only were the ports totally inadequate, but owing to the lack of communications it was impossible to find any other localities as temporary bases.

In the others, viz. Gallipoli, Mesopotamia, Palestine (Kantara Base) and German South-West Africa, ports were either non-existent, or virtually so owing to their very poor state of development.

2. Engineer work required in any campaign may, therefore, vary from the comparatively small task of providing additional unloading facilities and transit sheds, with perhaps a few wharves, to the virtual construction in a temporary form of a port with its complete equipment.

In any case the construction of the various base depots and installations will have to be undertaken on the lines already indicated in Parts IV and V.

When it is not possible to have a separate port for use as a temporary base, temporary depots should be constructed in the first case clear of sites selected for the permanent depots, whenever possible. Neglect to do so is bound to cause delay, confusion and bad organization at the permanent base.

3. This chapter therefore analyses the work which may be required under these varying conditions in the docks area itself, giving brief descriptions, as appropriate, of the various works which may become necessary.

This analysis will be considered under three heads :—

i. Work required on a temporary base which it is not intended to expand into the permanent base.
ii. Work required in the development of an existing port forming part of a permanent base.
iii. Work required in the development of a docks area where there is either no port in existence, or where facilities are so scanty as to be virtually non-existent.

It must be appreciated that the efficient working of a docks area is primarily a transportation problem, and that the engineering work required is determined solely by transportation needs. Thus the provision and siting of wharves must be governed entirely by the necessities of the railway lay-out, and engineering considerations must be subordinated to this.

181. Engineer work on a temporary base

1. The temporary lay-out will be required to function as such for the duration of the time it will take to develop the permanent one.

This will be partly dependent on the facilities already in existence at the selected port or ports, but will be governed chiefly by the time required to construct the various depots, etc., and their rail communications. (Parts IV and V, and Military Engineering, Vol. VIII.)

It is obvious that this period will be measurable in months rather than weeks; so that under certain conditions the temporary lay-out may well function for as long as six months.

Even with a period as long as this conditions demand that any engineer work carried out shall be of as temporary a nature as possible.

Any considerable work undertaken in this temporary lay-out must of necessity detract from the magnitude of the effort in the development of the permanent one, even though the organization responsible for the latter is entirely separate from the expeditionary force (F.S.R., Vol I, 1930, Sec. 89, 6).

In certain cases a temporary lay-out may, however, continue to function in a subsidiary capacity as such even after the permanent one has been brought into use.

2. Engineer work will, therefore, be limited to the strict essentials required.

These will usually be :—

i. The development of water supply.

ii. The construction of accessory camp structures in the various temporary base camps.

iii. The installation of electric light, or improvement and extension of an existing system.

iv. The construction of transit sheds for perishable stores in the dock area.

In many cases the selected port may be sufficiently well equipped to obviate any need for additional sheds.

v. The supplementing of facilities for discharging vessels by the provision of cranes, etc., and perhaps by the construction of temporary wharves.

vi. The construction of temporary depots and workshops.

Although in exceptional cases it may prove necessary to site these depots in the dock area, making use of existing dock warehouses, etc., every effort should be made to avoid this. On the other hand the necessity for concentration of effort on the development of the permanent lay-out, especially as regards railway communication, will effectively prevent the construction of depots at any considerable distance outside the docks area.

Large warehouses and similar buildings outside the docks area, but served, if possible, by the existing railway system (if any) and with good road access, should be made use of and adapted as required.

In the same way existing workshops, garages, factories, etc., must be fully used for the various temporary workshops required.

3. The nature of the work required under items i., ii. and iii., para. 2, above, has already been considered in this volume ; and any work under iv. and vi. will be carried

out with universal shedding (Chapter IV) if available; or, if not, on similar lines with materials purchased or requisitioned locally.

The construction of wharves, however, represents a considerable engineer effort, takes time and requires material which would in all probability be more usefully employed in the development of the permanent lay-out.

Such work should, therefore, only be undertaken after careful consideration of all the attendant circumstances.

One or more wharves may, however, be essential for the maintenance of the force, more especially to deal with petrol and oil in cases where the port has no facilities existing for that purpose.

4. The provision of unloading facilities is considered in further detail in Sec. **186**, and commercial types of plant are dealt with in Chapter XXXIII.

Although it may be necessary to improvise cranes or derricks to supply an immediate need, these should be replaced as soon as possible by power-driven shore or floating plant obtained from home or elsewhere; these, on the opening of the main base, can easily be transferred to it.

The construction of wharves is dealt with in Secs. **184** and **185**.

182. Work required in the development of an existing port forming part of a permanent base

1. It will be seldom that a port will be found of sufficient size and sufficiently developed to render additional work unnecessary to fit it for use as a permanent lay-out; but the amount and nature of the engineer work required depends so much on the existing capacity of the selected port that it can only be indicated on very general lines.

2. Apart from the base depots considered in Part IV, and the railway work dealt with in Military Engineering, Vol. VIII, engineer work will comprise one or more of the following :—

i. **The amplification and/or modification of the existing facilities for discharging vessels.**—These may consist of cranes or conveyors or both, and the various factors governing their selection and employment are considered in Sec. **186**.

Commercial types of cranes and elevators are dealt with in Chapter XXXIII.

ii. **The provision of power-driven trucks** to expedite the handling of stores in and out of the transit sheds.

Notes on commercial types are also included in Chapter XXXIII.

In connection with (i) and (ii) above it cannot be overstressed that the whole efficiency of the port will

depend on the rapidity with which cargoes can be cleared from the quayside and out of the docks area, and that a proper balance must be established between off-loading facilities, internal handling facilities and evacuation from the docks area by rail (*see also* Military Engineering, Vol. VIII, Chapters III and V).

iii. **The provision of additional wharves.**—The necessity for these will be entirely dependent on the amount of existing quay space, and on the size of the force to be based on the port, which will in turn govern the average volume of shipping which will have to be dealt with by the port at any one time.

Engineering considerations are dealt with in Secs. **184** and **185**.

Data on port capacity are given in Military Engineering, Vol. VIII, 1929, Sec. 8.

iv. **The provision of additional transit shed accommodation.**—The necessity for this will be dependent entirely on the amount already in existence, but it may be taken for granted that transit sheds will have to be provided with any new wharves constructed, except in the case of one constructed solely for oil and petrol in connection with a bulk storage installation (Chapter XXIII).

Where provided they will normally be of standard shedding.

v. **Extensions to the existing electric supply system.**— The increase of activity in the port, and the amount of night working which will be necessary, will almost certainly necessitate considerable extensions to any existing system; and in certain cases electric cranes may be installed as well as hydraulic or steam ones (*see also* Sec. **186**).

vi. **Extensions to water supply.**—These may include locomotive storage and filling points, fire protection, and the provision of drinking water for working parties at various points in the docks area, and for troops and animals landing or embarking.

183. Work required in the development of a port area where there is either no port in existence, or where the facilities are so scanty as to be virtually non-existent

1. It must be assumed that the force covering the construction of the base will have effected its landing: and the first essential is therefore to provide for its maintenance.

The stores, equipment, ammunition, etc., required will, in

the first instance, have to be off-loaded from ships at anchor into lighters which will have to be towed to the shore or bank and off-loaded by hand; and at this stage all that can be done is to provide movable gangways or ramps to facilitate the off-loading of the lighters.

This is a very slow and laborious proceeding, and piers and/or quays should be begun as soon as possible.

At first these will have to be floating, either made from the equipment carried by the force, or from boats, etc., obtained on the spot.

2. The construction of floating piers is dealt with in Military Engineering, Vol. III, and all that is necessary to note in this connection is:—

i. that the capacity of floating piers to deal with the discharge of stores is very limited;
ii. that they are unsatisfactory in tidal waters or strong currents, and probably cannot be used in a storm, even if they survive it;
iii. that the transfer of any considerable weight from lighter to pier head is a matter of difficulty, as derricks, etc., are almost impossible to instal on a floating platform unless it is very substantial;
iv. that the head must be as strong as possible, and securely moored to resist the impact of lighters coming alongside;
v. that the head must be long enough to accommodate the length of a lighter, and large enough to hold the whole of one lighter load together with men for handling, etc.;
vi. that if evacuation is by wheeled vehicle there must be room for a vehicle to turn.

3. A floating pier can rarely be made strong enough to withstand the impact of an ocean-going vessel coming alongside, even of small capacity, and it is usually a waste of effort to attempt to construct one. Normally it is sufficient to carry a floating pier far enough out to enable lighters to come alongside at all stages of the tide, although in extreme cases even this can be dispensed with, and the extra equipment which would be required more usefully employed in forming other piers.

It should be obvious from the foregoing that floating piers can only be regarded as very temporary expedients, and that they should be replaced by more permanent construction at the earliest moment.

4. In some cases a more serviceable floating pierhead can be made by using lighters, and by connecting them to the shore or to a fixed pier by box girders (service equipment).

The lighters could be held in position by piled dolphins.

This would provide a ramp for use in tidal waters, and vessels of moderate size could make use of it ; but it still has the disadvantage that the clearance of stores must be by hand.

Floating cranes could be used between the pierhead and the vessel or, with large lighters, derricks of small capacity could be erected on the lighters.

5. The ultimate result to be aimed at is a series of wharves in water sufficiently deep to permit of ocean-going vessels coming alongside at all stages of the tide, and of sufficient size and strength to withstand the impact and to carry power-driven derricks and cranes, and broad gauge sidings if a railway exists or is contemplated.

The number and extent of the wharves to be provided will depend on the strength of the force and on the size of the ships supplying them (*see* Military Engineering, Vol. VIII, 1929, Sec. 8).

6. The time and material required will render the construction of quays impossible except where deep water can be found close to the bank or shore. It should be possible, however, to undertake a certain amount of dredging, and this may come in useful if land reclamation has also to be undertaken as part of the port construction.

The construction of wharves (quays and jetties) is dealt with in Sec. **184**.

7. Where for one reason or another quays or jetties are impossible piers should be provided.

The ideal arrangement is for the piers to be built out sufficiently far to enable ocean-going vessels to berth along either side.

They can be either at right angles to the shore line or inclined to it to suit convenience of access, and any series of piers should be far enough apart to enable a ship to come alongside one, while a ship is berthed at the adjacent one, *i.e.* about 250 ft. Such piers, apart from their length, would have to be very strongly built, and at least 50 ft. wide, and would require a very large quantity of material for their construction. They have the advantage, however, that broad gauge lines can be run down them without difficulty.

In most cases, therefore, all that will be possible will be a pier with a T-head along which vessels can moor.

Although the head would have to be substantial the pier itself would not exceed 12 ft. in width, sufficient, in fact, for the working of the transport to clear the stores from the end, or for a double line of 2-ft. gauge railway.

In extreme cases it may only be possible to provide piers to deal with lighters, in which case less solid construction can be adopted throughout.

8. Solid piers will seldom, if ever, be constructed. Their siting requires very careful consideration and observation of the set of the tide, currents and storms over an extended period ; otherwise they may be complete failures. They also take a long time to construct, and require vast quantities of material.

If successful, however, they usually provide a sheltered anchorage on one side or the other, and permit of work being carried out in stormy weather which would be impossible otherwise.

In any case piers should be sited in as sheltered places as possible, and it is worth incurring a considerably longer movement by land to obtain this.

9. Normally piers will be piled, either in timber or reinforced concrete, or both.

As explained above it will usually be almost impossible to carry a broad gauge line down a pier, and the method of evacuation of the stores must therefore be considered.

If by lorry or horsed transport, the means of access and exit should be separated.

The most satisfactory method is by light railway (2-ft. gauge), if possible with petrol tractors.

A double line should be provided with at least two lines at right angles along the pierhead. These should be connected with the lines on the pier by curves, and with each other by cross-overs.

Turn-tables should be avoided, if possible, owing to the delay caused in handling each wagon separately.

The outer line should be set sufficiently far back to allow for the siting of derricks, and of stacking 10 ft. deep between it and the ship.

The best method is to construct two piers, each about 12 ft. wide and 120 ft. apart, so that they come roughly opposite the holds of an average sized ocean-going vessel.

T-heads are constructed to each, not less than 20 ft. wide and preferably 30 to 40 ft., and the inner portions of the Ts connected together.

The two 12-ft. piers provide for the circulation of wheeled traffic, or can each carry a double line of 2-ft. gauge light railway. Whichever method is adopted, it must be realized that stores should be transferred to broad gauge line as soon as possible (preferably immediately at the pier entrance) for conveyance to the various depots, and that as far as possible these other means of conveyance should be confined to the purpose of clearing pierheads only.

Where for various reasons it may be impossible or unnecessary to provide piers for ocean-going vessels, piled

piers on similar lines should be provided for lighters in replacement of the original floating piers.

The construction of piled piers is dealt with in Sec. **185.**

10. Whether quays, jetties or piers would be provided is dependent on actual conditions. In a river port quays should normally be possible and any dredging required should present little difficulty. Piers and jetties which would be liable to obstruct navigation must be avoided.

On a sea-coast, particularly with a shelving beach, piers are usually the only possible solution.

184. Construction of wharves (quays and jetties)

1. In exceptionally favourable cases, where deep water is found close in to the bank or shore, it will be possible to construct quays for ocean-going vessels without excessive projection beyond the shore line. In other cases, it will be found much more economical in time and material to construct a jetty of sufficient length to berth the vessel, and of sufficient width to carry the necessary cranes only, and merely connect it with the shore by a gangway. The distance out is governed by the command of the cranes installed ; it must be possible to reach a broad gauge line on the shore from them. This arrangement has the further advantage of allowing barges or lighters to come in between the wharf and the shore and to be off-loaded or loaded simultaneously with the ship (Pl. **122,** Fig. 1).

2. Whichever arrangement is adopted on active service, wharves will always be piled—any other method of construction will be too elaborate and lengthy.

For the same reason wharves will never be made solid, unless they have to be constructed on reclaimed land where a retaining wall is essential. Even in such cases fills will be greatly reduced by keeping the retaining wall as far back as possible.

Where possible timber piles and decking will always be employed, as they are far easier to work with ; but where timber is not available steel or reinforced concrete piles will have to be employed.

The construction of the latter is dealt with in Sec. **145.**

Splicing reinforced concrete piles is a slow and cumbersome procedure, and it is advisable to err on the safe side by providing a good margin of safety in the original length of the pile.

The bearing power of piles, pile-drivers and methods of driving are dealt with in Military Engineering, Vol. III.

3. Whether timber, steel or reinforced concrete piles are used, the general principles of quay construction are the same.

The load (distributed dead load) capacity will depend entirely on the use to which the quay will be put, and ranges from 250 to 1,200 lb. per sq. ft. The minimum should be used for piers used solely for berthing light traffic, and for the support of oil and water pipes ; and the maximum for the quays for handling heavy guns, locomotives, etc. In view of the very solid construction required for such loads every effort should be made to handle them on existing quays.

The normal load can be put at 500 to 750 lb. per sq. ft., to which should be added the dead load of the superstructure itself.

Under active service conditions it is sufficient in designing wharves to allow for decking to carry the full superimposed load.

Stringers and beams to carry the full load.

Bent caps or girders 80 per cent. of the load coming on them.

Piles or columns 75 per cent. of the load coming on them.

The foundations for the broad gauge track and heavy crane tracks require special treatment, and must be calculated independently of the remainder of the structure.

4. The normal method of construction is to drive the piles in a series of bents—the distance apart of the bents being about 10 ft.

The number of piles required in a bent will vary with the conditions in each particular case, but in no circumstances should the clear space between the piles be less than 2 ft. 6 in. to 3 ft.

The tops of the piles are cut to level, and connected together with a cap or girder of sufficient strength to carry the deck beams.

Caps are normally secured to piles by drift bolts. If caps have to be spliced the joint (a halved joint) should be over a pile, and the joints should be staggered through the length of the quay.

In addition the piles are braced to each other with horizontal and diagonal bracing, which is preferably wedged in between the piles and secured with bolts and straps, but which in very temporary work can be bolted on to the sides of the piles.

This bracing should be kept above the mean low-water line.

To resist the shock of impact of vessels coming alongside it may sometimes be necessary to anchor back each bent. This can be done by driving in one or more raking piles or by securing the bent firmly to anchor piles driven into the bank.

The bents are connected to each other by stringers and walings.

Walings are placed longitudinally along the front of the bents and are bolted on to the end piles. In some cases they may be halved on to the piles.

If the bents are of considerable depth, *e.g.* over 30 ft., intermediate stringers are advisable to give additional rigidity to the structure. They are usually secured in the same manner as walings.

Vertical fenders are fixed at frequent intervals to the walings, or preferably slightly battered fender piles can be driven along the front of the quay.

Rubbing or wearing ribands, which can be replaced when worn out, should be fixed horizontally to the faces of all fenders or fender piles.

The decking is carried on beams or stringers which should be of a size and spaced for the calculated load.

These beams are carried on the bent caps, and should be secured by drift bolts. For light loads dogging is sufficient.

They can be either butt-jointed on the caps and drifted or spiked, or if the joint occurs in the middle of the bay the timbers are fish-plated.

The decking should be not less than 3 in. thick in more permanent work, with a wearing surface of 1½-in. timber laid diagonally on the surface. It should be spiked on to the beams.

Types of construction of timber quays are given on Pl. **121**, Figs. 1 to 5.

5. With reinforced concrete, construction is more complicated, as the stringers, bracings, etc., must be made monolithic with the piles.

In such cases, it may be simpler to make the deck of reinforced concrete as well and incorporate it as part of the structure.

Timber fenders or timber fender piles will be required at every bent.

Types of construction of reinforced concrete quays and jetties are given on Pl. **122**, Figs. 1 to 4.

6. If retaining walls are required they can be conveniently made of sheet piling either of timber or concrete, and incorporated in the structure.

In such cases raking piles may also be required to resist the earth pressure, and a type of construction as in Figs. 3 and 4 may have to be adopted.

Where the back fill is inconsiderable, close horizontal walings fixed to the shore piles may be sufficient, supported, perhaps, in the intervals between the bents with short piles anchored back to holdfasts buried in the bank.

7. The table below gives the ruling dimensions of cargo vessels up to a gross tonnage of 10,000, as a guide to the quay construction which may be necessary in any particular case.

TABLE R.—RULING DIMENSIONS OF CARGO VESSELS

Category.	Draught.	Length.	Breadth.	Tonnage. Gross.	Tonnage. Net.
Ships ...	15 ft.	230 ft.	33 ft.	1,000	67 per cent.
	19 ,,	280 ,,	39 ,,	2,000	
	21 ,,	330 ,,	44 ,,	3,000	
	23 ,,	360 ,,	48 ,,	4,000	
	25 ,,	390 ,,	51 ,,	5,000	
	26 ,,	420 ,,	53 ,,	6,000	
	27 ,,	440 ,,	55 ,,	7,000	
	28 ,,	450 ,,	57 ,,	8,000	
	28 ,,	460 ,,	58 ,,	9,000	
	29 ,,	470 ,,	59 ,,	10,000	

Category.	Draught. Loaded.	Draught. Light.	Length.	Breadth.	Tonnage.
Barges ...	7 ft.	2 ft.	70 ft. 6 in.	20 ft. 4 in.	150
	6 ,,	2 ,,	69 ,, 6 ,,	18 ,, 0 ,,	110

There are very few barges of capacities exceeding 250 tons apart from the closed-in Medway sailing type barge.

Typical dimensions of these sea-going types are :—

Draught. Loaded.	Draught. Light.	Length.	Breadth.	Sea tonnage.	Inland water tonnage.
7 ft. 9 in.	2 ft.	124 ft.	16 ft. 4 in.	180	280
13 ,, 9 ,,	3ft.-3ft.9in.	180 ,,	31 ,, 0 ,,	1,000	1,500

185. Construction of wharves (piers)

1. As stated in Sec. **183** the vast amount of material and time required will usually make it impracticable under active service conditions to construct piers along either side of which ocean-going vessels will be able to berth.

In the unlikely event of such piers being possible they would be designed and constructed on similar lines to jetties.

Typical piers are illustrated on Pl. **123**.

If ships are to berth on either side a double set of raking piles will be necessary, as illustrated in Fig. 2, and a double broad gauge line would be desirable.

2. Normally, however, the most that could be done would be to provide a pierhead along which vessels could be berthed.

The depth of water at the pierhead should be sufficient for the type of vessel using it, *e.g.* up to 30 ft. at low water for ocean-going vessels, and 5 to 7 ft. at low water for barges or lighters.

The length of the pierhead should be sufficient to extend just beyond the holds of the vessels using it, *e.g.* not less than 240 ft. for ocean going vessels, or 180 ft. for barges and lighters.

The width should be not less than 30 ft. *i.e.* wide enough to withstand impact and to allow for a double line of decauville or lorry transport, with a minimum stacking space of 10 ft. for accumulations of stores awaiting clearance to the shore. With lighters this width could, if necessary, be reduced to 24 ft., but a 30-ft. width is desirable if it can be attained.

The construction of the pierhead is on the same general lines as indicated above.

The maximum load which must be taken into consideration need not exceed 250 lb. per ft. super, with barges, or 500 lb. per ft. super with ships.

3. In most cases ocean-going vessels would discharge with their own derricks, as the ruling factor will be the rate at which stores can be cleared from the pierhead; but with lighters, etc., derricks or cranes must be provided, preferably power-driven.

4. The connections between pierhead and shore need only be of light piled construction, 12 ft. wide, with bents of 4 8 in. by 8 in. piles in 10-ft. bays; caps, bracing and decking will be correspondingly light, and designed for the type of transport using the pier.

If horsed transport is employed substantial railings must be provided.

Wherever possible two connections should be given, one opposite each main hold. This will expedite the clearance of stores, and allow of circulation of traffic, if lorries or horsed transport are employed.

5. The outer ends or corners of the pierheads should be protected by heavy clusters of fender piles or by separate pile clusters or dolphins. These can also be made use of as moorings. In addition, mooring piles or bollards, bitts and cleats should be provided at 50-ft. intervals along the berthing space.

If the evacuation of stores is by decauville, turn-tables may be required on the pierheads (*see* Sec. **183**, 8), but the shore ends should be widened to admit of trains turning off the pier and running along a broad gauge line.

It is essential that the transference of stores to the broad gauge system should take place at the earliest possible moment.

A pier of this type is illustrated on Pl. **124**.

6. With both jetties and piers mooring bollards will be required.

A common practice is to drive longer outer piles for those required as mooring piles. In bents in which the outer pile becomes a mooring pile, the bent cap can no longer be carried on the heads of the piles, and the cap is formed of two timbers bolted through on either side of the piles, which are also shouldered out to receive them (Pl. **124**).

Mooring bollards should be fixed about every 50 ft.

If time and materials permit a better practice is to drive separate piles to act as mooring piles, and to tie them in securely to the main structure (Sec. **186**, 6).

186. Port and quay equipment

1. All developed ports can be assumed to be provided with equipment to meet their normal working purposes, but this equipment will rarely be sufficient or entirely suitable for military needs in war. The more modern and up-to-date the port, the more likely will its equipment be found satisfactory, but as most ports are designed for export as well as import trade, and as military traffic will be almost entirely an import one at an overseas base, amplification and modification of the existing equipment will usually be found necessary. This may be more particularly the case as regards off-loading facilities, where military needs will usually require very rapid off-loading to release shipping for further journeys.

Port or quay equipment which may require such amplification or modification may be taken to comprise cranes, conveyors, capstans, warehouse and transit sheds, mooring bollards, water and power mains, and lighting.

2.—i. **Cranes.**—Most modern docks and wharves are fitted with cranes driven either by hydraulic power or by electricity. Steam cranes may still be found in less developed ports, or in isolated positions beyond the reach of the power mains, or where cranes, under the normal working of the port, are only required for occasional use.

ii. The type and capacity of existing cranes will have been decided by the nature of the goods to be handled, and the method of working in the port.

Whilst, therefore, the most common type is the Portal crane, spanning one or more railway lines on the quay, in some cases, owing to the narrowness of the quay, the semi-Portal type may be found, and in others the cranes may be fixed. Again, to deal with special uniform types of cargo, conveyors, suction plant or other types of special handling plant may be found installed.

iii. The military necessity for the rapid discharge of cargo may often require a greater concentration of off-loading facilities at any one point than may be provided for normal working, and it consequently demands the greatest flexibility in the use of such facilities.

As a general principle, therefore, it may be assumed that the maximum attainable rate of discharge must always be aimed at, although in practice this may be modified by the consequential inability of the transportation services to clear away the accumulations with sufficient rapidity through shortage of rolling stock or for other reasons.

It is, however, a cardinal principle that on no account whatever must the docks area be used as anything but a transit area, except where it cannot be avoided in ports used as temporary bases (Sec. **181**, 4, and Military Engineering, Vol. VIII, 1929, Sec. 31, 2).

iv. Except for heavy individual loads a crane capacity of 30 cwt. per lift has been found the most convenient, and loads of this size deposited on the quay at 1½-minute intervals by each crane can be dealt with by hand trucking without congestion on the quay.

With electric trucking this rate can be doubled, and for most purposes, therefore, a double powered crane with capacities of 30 cwt. and 3 tons should meet requirements.

For general port working the rates given in Military Engineering, Vol. VIII, 1929, Sec. 8, 3, are not likely, however, to be greatly exceeded over considerable periods, allowing for delays between berthing of vessels.

v. With the average sized ocean-going cargo vessel the maximum number of cranes which can work simultaneously with any convenience is two on each main hold, and one each on fore and after holds, or a total of six.

On a jetty or quay with more than one berth, if mobile cranes are available, it will not be necessary to provide this number at each berth, as it will seldom occur that adjacent berths will be occupied by ships under the same conditions of discharge, and the flexibility given by self-propelling mobile cranes will allow of a general average of one crane per 90 ft. of wharf as sufficient for the most rapid work.

vi. To cope with heavier military loads there should be one 10-ton crane to every four to six 30-cwt. ones, and for exceptional loads such as locomotives a 100-ton floating crane will be necessary. Fixed cranes of this capacity will seldom be found in any port and are unsatisfactory, as they necessitate the moving of any ship with extra heavy loads to a particular berth.

vii. For loads up to five tons, hydraulic cranes are probably

preferable on the whole to electric ones; above this weight electric cranes have almost entirely replaced the former type.

If not already in existence, however, the installation of a hydraulic system would be too slow and complex an undertaking in wartime, whereas an electrical distribution system is comparatively simple (para. 7, iv, below).

viii. Commercial types of cranes and their performances are considered in Sec. **188.**

3. **Conveyors, etc.**—

i. Conveying machinery may be found installed in any modern port. It can be divided into two main classes :—

(*a*) Machinery fixed in warehouses, etc.

(*b*) Machinery of a mobile type for the loading and off-loading of ships.

ii. It comprises some or all of the following :—

An **elevator,** to raise goods from the hold of the ship to the surface, or from the quay to the upper floor of a warehouse.

A **conveyor,** to carry the goods horizontally or on a slight gravity incline.

A **lowerer,** to drop goods to the ground level, either from the deck of the ship to the quay, or from an upper floor to a lower floor of a warehouse, and sometimes—

A **piler,** for the stacking of goods as required.

By combining these operations in one apparatus a saving of power can be obtained, as the energy generated in the lowerer, for instance, can be made use of.

iii. There are various forms of conveyors, each adapted for a particular type of load, *e.g.* grain sacks, tea chests, etc.

The most suitable type for military cargoes is the slat conveyor, which can deal with a considerable variety of mixed packages.

This and other commercial types are described in Sec. **189.**

A specialized type of conveyor in the form of suction plant is of very great value in dealing with cargoes of grain, and may be found installed in combination with large grain storage installations.

iv. If conveyors, etc., are not found already installed in the base port it is extremely doubtful whether it will be worth while installing them.

Their field of employment is limited, and they are most useful when cargo is being stored in the port warehouses.

Where quick evacuation of goods from the dock area is required, cranes and hand or electric truckage give better general results, always excepting the special cases where storage for special goods may exist in the docks area, *e.g.* for grain, frozen meat, and perhaps coal.

4. **Capstans.**—Capstans are employed for hauling on ships' ropes to assist them to enter or leave a dock or come alongside a wharf. Occasionally they may be used for hauling railway trucks.

They will usually be operated either electrically or hydraulically.

It is unlikely that capstans would be installed specially in a base port in a campaign; as, if none exist, ships can always come alongside by using their own winches and hauling on to fixed bollards.

5. **Warehouses and transit sheds.**—

i. The existing warehouses in any port may be of a wide variety of types.

In many cases they are used for storage as well as for transit purposes; in some cases they may be of two or more storeys, of which the upper are used for storage and the ground for transit; or again with two floors the upper may be for import trade and the ground floor for export.

Whatever the normal arrangement in the port the warehouses and sheds taken over for military purposes will be used for transit purposes only.

ii. Where extra sheds are required, particularly with any new wharves or piers which have been constructed, they will be normally of standard design and span.

iii. The width will conform to the space available as regulated by the required width of the wharf and the lay-out of sidings, and will be made up of one or more standard spans.

iv. It is very desirable that transit sheds should be fire-proof, and the construction should therefore be preferably of steel framing and galvanized corrugated iron.

v. Good lighting both by day and night is necessary, and roller or sliding doors should be provided at 50-ft. intervals.

vi. Long sheds should be divided up at 200-ft. intervals by partitions of brick or other reasonably fire-proof material. These partitions should extend up to the roof.

vii. The floors must be solid. The internal traffic will be extensive, and loads considerable. The floors should be, therefore, of concrete, or at least definite runways for the trucks should be so constructed.

viii. On one side of the shed, usually the further one from the wharf, a loading platform will be required, which should be not less than 19 ft. in width and covered over; the clearance at the outside edge of the roof must be sufficient to clear the maximum loading gauge.

6. **Mooring bollards.**—Modern bollards are generally of cast iron.

There are four common types, (i) Plain circular cross

section. (ii) Circular cross section with whelps. (iii) Plain rectangular cross section, with rounded corners, and (iv) the same with whelps. (Pl. **125**, Figs. 1 to 4.)

Of these the plain circular section type is the best for moorings.

They are provided with a lip at the top to allow of ropes leading up to the high decks of ships without slipping off.

The usual method of fixing is by setting the bollard some 3 ft. into a block of concrete not less than 8 ft. cube, unless the bollard is carried on and built into the quay wall itself. The bollard itself should be filled with concrete.

Bollards are usually fixed on the edge of the quay to avoid interference with railway and crane rails. A method of fixing a bollard in this position is given on Pl. **126**.

With reinforced concrete wharves the bollards can be incorporated in the structure of the wharf, but with timber piled wharves and jetties it is advisable to drive separate mooring piles tied in to the timber structure, and projecting through the decking. Alternatively the outer piles of bents may be made use of (Sec. **185**, 6).

Bollards should be provided at approximately 50-ft. intervals along a wharf.

7. **Power and water mains.**—

i. In all modern ports power and water mains are carried in pipe subways formed in the upper part of the quay wall.

Hydraulic hydrants for crane connections and electric plug boxes for electric cranes should be about 25 ft. apart along a berth, and fire hydrants on the water mains at about 50-ft. intervals.

ii. Hydraulic mains are of cast iron and should be coated inside and out with Dr. Angus Smith's composition. The usual working pressure is 800 lb. per sq. in., and the velocity should not exceed 3 ft. per second.

In considering extensions to an existing system under the normal conditions found in a reasonably new hydraulic system, a 2-in. pipe connection is required to supply a single 5-ton hydraulic crane (which utilizes about 60 b.h.p.).

A 3-in. pipe would be required for two similar cranes, and a 4-in. pipe for four cranes.

It the pipes are old, there will be a reduction in the power transmitted for any given size amounting to as much as 40 per cent. after 25 to 30 years' use.

In making additions to an existing hydraulic system it will usually be necessary to introduce booster pumps to maintain the working pressure, which will fall off considerably with friction, leakages and draw-offs of machinery.

iii. With timber quays or jetties, pipes and power mains should be laid in troughs formed of timber under the deck,

which, as a protection against frost, should be filled with sand or sawdust.

With reinforced concrete quays, etc., a pipe conduit should be constructed underneath the deck, and suspended from the cross beams at their haunches.

iv. Electric transmission.—Direct current working is found to be the most satisfactory for dock plant, at a voltage of 500 for power and 250 for lighting. Drop in voltage in the main can be got over by the provision of feeder mains tapping in at various points.

Bare overhead mains can usually be provided.

Electric cranes pick up their current either by means of ploughs travelling in slot conduits under the quay from bare conductors (Pl. **127**) or by means of flexible cables and quay plugs.

The slot conduit is liable to get filled with dirt and rubbish, whereas the flexible cable system limits the crane to a movement of 25 ft. in either direction without changing over to another plug. In practice this is not found to be a serious disadvantage, and the system is far cheaper and simpler to instal.

8. **Lighting.**—Wide distribution of light with absence of shadows is required rather than a great intensity of light, and gas-filled lamps with a suitable dispersive reflector are more satisfactory than arc lamps.

Lights should be fixed on standards well above the quay, and the standards must be clear of all cranes and other quay appliances.

On jetties and piers it is advisable to place hoods over the lights, projecting the illumination downwards so as to give no chance of confusion with navigating lights. As the electric light standards themselves cast appreciable shadows, the lights should be suspended on the inner or quay side of the standards.

The candle-power installed, and the distance apart of the standards, will depend on the height, but generally speaking it is desirable that the lights should be well above the deck of the ship berthing and preferably above the top of the crane jib, *i.e.* at least 90 ft. high, and the candle-power of each globe should be not less than 1,000.

One standard opposite each hold of the ship, or four for each berth should be ample for all purposes.

With piled jetties it will usually be quite impossible, and in fact unnecessary, to erect lamp standards of this height, and the best arrangement possible in the circumstances must be accepted instead.

With barge or lighter traffic, the lights need only command the vehicle or truck into which supplies are to be loaded, and a height of 12 to 16 ft. for standards will be ample.

CHAPTER XXXIII

MECHANICAL HANDLING OF MATERIALS

187. General

1. Mechanical appliances designed to economize in time or manual labour in the handling of material in a theatre of war fall into five main categories.

i. **Dock equipment.**—*E.g.* quay and floating cranes, conveyors, etc.

Their primary function is to expedite the off-loading of ships, and to deliver the cargoes to other transportation agencies. Port requirements have been considered in Sec. **186.** Commercial types and performances are dealt with in Secs. **188** and **189.**

ii. **Depot equipment.**—*E.g.* run-about cranes, mechanically propelled trucks, conveyors, pilers, etc., and tramways.

Their primary function is to minimize the labour and time required for all internal depot working, whether for loading or off-loading railway wagons and/or road vehicles, or for stacking and storing in the depot.

iii. **Workshop equipment.**—*E.g.* gantries, overhead travelling cranes, conveyors, etc.

These are required for the handling of heavy loads to facilitate workshop operations (Sec. **165**).

iv. **Long distance conveyors.**—*E.g.* aerial ropeways (Chapter XXXIV).

Their chief utility is where other forms of transportation fail.

Light railways may also come under this category.

v. **Constructional plant.**—*E.g.* excavators, pile-drivers, stone crushers, road rollers, concrete mixers, etc.

Pile drivers are dealt with in Military Engineering, Vol. III ; excavators, stone crushers and concrete mixers in Chapter XXXV of this volume. Road rollers are dealt with in Military Engineering, Vol. V.

2. Pumping plant, generating plant, and engines and machinery in general are dealt with in the Text-books of Mechanical and Electrical Engineering and are not considered any further in this volume.

188. Quay cranes

1. The most suitable type of quay crane for general purposes is the self-propelling Portal type, capable of revolving in a

complete circle, but the semi-Portal type may have to be employed where the warehouses are close to the quayside. Travelling roof or fixed cranes may be necessary in special cases where the warehouses are built on the water's edge.

Most modern cranes are provided with balanced level-luffing gear, with which by means of a small hinged arm at the end of the jib, the jib can be "luffed" without altering the level of the load. This saves unnecessary hoisting, and enables the driver to place his loads accurately and avoid fouling rigging, etc.

The motive power may be hydraulic, electric or steam (Sec. **186**). Modern cranes are designed to travel under load slowly. Older ones are not, and if made to do so to any extent give trouble.

2. **Hydraulic cranes.**—

i. Hydraulic cranes are the fastest, achieving hoisting speeds of 250 to 300 ft. a minute, and slewing speeds of one revolution a minute.

ii. They are fitted with rams for hoisting and luffing, but for slewing hydraulic capstan engines are preferable to rams, as the latter limit the possible slew to about 230 degrees on either side.

The hydraulic supply is taken from the nearest hydraulic hydrant and passes up the centre of the crane post and pivot.

iii. Hydraulic cranes are usually built with plated frame structures, but a considerable saving in weight can be effected by making them of lattice steel similar to the construction generally adopted for electric cranes.

iv. A typical performance for a modern 30-cwt. hydraulic crane is as follows :—

Hoisting speed ...	250 to 300 ft. a minute.
Slewing	1 complete revolution a minute.
Luffing	150 ft. a minute.
Range of hoist ...	From 30 to 40 ft. below quay level to 65 ft. above.
Maximum outreach ...	65 ft.

Water consumption :—

For lift of 90 ft.	35 gals.
For lift of 45 ft.	12 gals.
For slewing one revolution	8 gals.

A modern 30-cwt. hydraulic crane is illustrated on Pl. **128**.

3. **Electric cranes.**—

i. Electric cranes are usually more economical in their working than hydraulic ones, especially when worked below

their full capacity, as the consumption of current during hoisting is almost directly proportional to the load.

ii. Modern electric cranes are fitted with level luffing gear, of which there are a number of patented forms.

iii. Cranes may be on either D.C. or A.C. supply, common voltages being 480 D.C. or 400 A.C., 3-phase, respectively. In the former case current is picked up from ploughs travelling in underground slot conduits; from bare conductors, which, however, are liable to interfere with slewing; or from plug points by flexible cable (Sec. **186**, 7, iv).

The various motions should be effected by separate motors for reliable and rapid movement. The motors are normally of the enclosed ventilated series-wound type, capable of taking an overload of 25 per cent. for five minutes, or 100 per cent. for half a minute without damage.

With A.C. cranes the supply would be normally H.V. to pole transformers, and thence by cable to plug points at approximately 100-ft. intervals.

Underground slot conduits are not suitable owing to the necessity for one conductor or wire for each phase.

iv. For cranes up to 2-ton capacity free barrel "lowering," *i.e.* with the speed of lowering controlled only by the brake, is suitable.

With D.C. cranes of greater capacity, and in many smaller modern D.C. cranes, potentiometer control is provided, by means of which, when the load is being lowered, the motor is converted into a generator, and the energy produced taken up by resistances. By this means the load is always under complete control.

With A.C. cranes hydraulic or elaulic brakes are provided, which pump the water or oil through a valve back to a tank.

v. A typical performance for a modern 2-ton (D.C.) electric crane is as follows :—

Hoisting speed	...	200 ft. a minute.
Slewing speed	...	1 complete revolution a minute.
Luffing speed ...	...	150 ft. a minute.
Travelling speed	...	50 ft. a minute (with ploughs and conduit).
Range of hoist	...	From 30 ft. below quay level to 85 ft. above.
Maximum outreach	...	65 ft.
Minimum outreach	...	24 ft.
Motors, lifting	...	40 b.h.p.
,, slewing	...	7 ,,
,, luffing	...	7 ,,
,, travelling	...	13 ,,
Current ...	...	480 volts, D.C.

The performance for a 2-ton A.C. crane would be very similar.

A typical 2-ton electric crane is illustrated on Pl. **129**.

4. **Steam cranes.**—Although steam cranes of varying types and capacities may be found already installed in any port, the only types of any general utility, and therefore likely to be installed in war at an overseas base, are those carried on railway mountings. These have the added advantage that they require no labour in installation, and can readily be obtained in considerable numbers from railway and docks companies in the United Kingdom.

In general, cranes of this type are not designed for fast travelling, and those of under five tons capacity are seldom fitted with self-propelling motion. This is a distinct drawback, as they require either to be pushed by hand from point to point, or the frequent use of an engine is necessary. As a rule the cranes have small coal and water capacity, and carry only about two to three cwt. of coal, and 100 to 150 gals of water.

Most cranes of this type have a jib derricking motion, and the jib can also be slewed on the crane carriage through a full circle. When travelling, the crane is locked in a longitudinal position for safety purposes.

Owing to their limited stability when lifting in a direction at right angles to the track, propping or blocking girders are employed except in the smallest sizes (1 ton). These are drawn out from the crane carriage and, when extended, are supported by jacks or blocks. Rail clips are also provided, which clip on to the track rails. By means of these appliances increased lifting capacity is obtained at the expense of the free travelling movement.

Two main series of safe working loads are given; one for each condition of working, *i.e.* "Free" and "Blocked up."

The maximum working load is painted on the crane in a prominent position, and the safe loads at various radii are clearly shown on an automatic indicator.

The cranes are designed to clear the railway loading gauge, and for this purpose the short chimney of the boiler is sometimes made to hinge, in order to give the necessary clearance.

Motive power is obtained from a small steam engine and a boiler, whose working pressure is from 80 to 120 lb. a sq. in. The boilers are of the vertical cross tube type, usually with two cross tubes, and two injectors are provided, or one injector and one feed pump.

The machinery is operated by two steam cylinders placed either vertically or horizontally, which through cast steel

TABLE S.—PARTICULARS OF TYPICAL TRAVELLING STEAM CRANES

Item.	Typical particulars.			
	10 tons maximum load.	5 tons maximum load.	3 tons maximum load.	$1\frac{1}{2}$ tons maximum load.
(1)	(2).	(3)	(4)	(5)
Capacity :—				
Free on rail	10 tons at 17 ft.	From 5 tons at 15 ft. To 2 tons at 28 ft.	From 3 tons at 16 ft. To 1 ton at 30 ft.	From $1\frac{1}{2}$ tons at 16 ft. To $\frac{3}{4}$ ton at 25 ft.
Propped up	3 tons at 30 ft.	From 5 tons at 18 ft. To $2\frac{3}{4}$ tons at 28 ft.	From 3 tons at 18 ft. To $1\frac{1}{2}$ tons at 30 ft.	From $1\frac{1}{2}$ tons at 18 ft. To 1 ton at 25 ft.
Speeds :—				
Full load—				
Hoisting	40 ft. a min.	60 ft. a min.	120 ft. a min.	130 ft. a min.
Travelling	300 ft. a min.	300 ft. a min.	300 ft. a min.	300 ft. a min.
Slewing	One complete rev. every 30 secs.	One complete rev. every 30 secs.	One complete rev. every 20 secs.	One complete rev. every 20 secs.
Boiler :—				
Dimensions	4 ft. by 6 ft. 9 in. high	3 ft. 9 in. by 7 ft. high	3 ft. 9 in. by 7 ft. high	3 ft. 9 in. by 7 ft. high
Working steam pressure	120 lb. per sq. in.	80 to 100 lb. per sq. in.	80 to 100 lb. per sq. in.	80 to 100 lb. per sq. in.
No. of axles...	3	2	2	2
Wheelbase	12 ft.	8 ft.	7 ft. 6 in.	7 ft.
Maximum axle load when travelling	18 tons	15 tons	11 tons	8 tons
Length over buffers ...	20 ft. 7 in.	19 ft. 6 in.	17 ft.	15 ft.
Jib length (centres) ...	33 ft.	30 ft.	30 ft.	25 ft.
Weight	60 tons	28 tons	$19\frac{1}{2}$ tons	15 tons

gearing operate the lifting, derricking, revolving and travelling motions.

Jaw clutches are provided for the various motions, with the exception of the revolving, which is fitted with reversible cone clutches. The carriage has two or three pairs of wheels, according to size, fitted with locomotive type axle boxes and springs.

The jib is usually constructed of steel plates and angles.

Table S on the preceding page gives particulars of 10-ton, 5-ton, 3-ton and $1\frac{1}{2}$-ton steam cranes.

An illustration of a typical 5-ton steam crane on a railway mounting is given on Pl. **130**.

189. Conveying, elevating, etc. plant

1. The value of conveying, elevating, etc., machinery lies in the rapidity and continuity with which goods are delivered, the economy of power and labour effected, and the elimination of unnecessary handling. The plant can be designed so that inspection and automatic counting and weighing can be done without interfering with the movement; sorting can also be readily carried out. For maximum efficiency such plant should be used for uniform cargoes or deliveries which do not require sorting.

2. Fixed conveying and elevating machinery is largely used under peace conditions, when ships can be berthed regularly opposite the warehouse in which their cargoes are to be stored. Such plant will, however, be less useful in war time, and a description of it is outside the scope of this book; moreover, its design is similar to that of the portable plant which will be described hereafter. Portable types are generally made in 25-ft. lengths mounted on castors, occasionally on wheels or tracks. Stands should be adjustable. Where power is required they may be driven electrically or by a portable petrol or steam engine, although steam plant is rather bulky for the purpose.

3. Such handling plant may be classified as follows :—

- i. Conveyors, for horizontal or slightly inclined movement.
- ii. Lowerers.
- iii. Elevators.
- iv. Stacking machines.
- v. Special plant, for delivery of meat, grain, coal, timber, etc.

Lowerers are generally linked with conveyors or elevators, so that the potential energy gained in lowering is not wasted.

4. Case goods will travel on rollers at a slightly downhill gradient. This is the simplest type of conveyor and with hand power is also suitable for horizontal or slightly uphill movement. Slats, mounted on a chain and driven by a belt, may be substituted, and are more suitable for mixed packages; or a band conveyor may be used, travelling on rollers. The driving rollers are normally convex in cross section, but the bearing rollers concave. These types can be sectionalized. A modification of the band conveyor is the canvas sling conveyor, in which each article is slung between slats; this enables one band to be used for elevating and lowering as well as conveying. In all cases special sections are required for changes of direction, unless the goods are run off from one section to another leading in the new direction, which means loss of height. This method can also be used for sorting.

5. For slopes greater than that at which a belt conveyor will carry goods, the canvas sling type should be used, or a modification of the slat type in which prongs or trays are fitted at right angles to slats at intervals: the prongs have the ends turned up, and both types can carry goods vertically up or down. The prongs may pass through slots in a platform and automatically pick up goods placed on it for elevating, or deposit goods when lowering.

Prong and sling types may be used continuously for picking goods up from the hold of a ship, conveying them ashore and lowering them into a truck or warehouse.

Cases and sacks can be lowered in inclined or spiral shutes.

6. Inclined band or slat conveyors may be used for stacking, where there is room, but for heavy loads or in a confined space the vertical platform type is preferable. Electric trucks are obtainable, which can elevate their platforms to a limited height, and the use of small runabout cranes for this purpose should be considered.

7. The detail of special handling plant is outside the scope of this book.

Grain is most rapidly handled by suction plant, which may give delivery of from 10 to 300 tons an hour.

The use of rails, complete with switches on which hooks run, enables meat to remain on the same hooks throughout its cold storage and handling.

For lowering carcases from upper floors of cold stores, shutes, either inclined or spiral, may be used.

Coal may be handled by grabs, transporters or telphers.

Timber requires manhandling, but can be lifted by special prong elevators.

A typical commercial pattern of conveyor and elevator, etc., is illustrated on Pls. **131** and **132**.

190. Yard cranes

1. Wherever transhipment of goods takes place, mechanical means of handling the traffic is almost essential for rapidity and efficiency. The need will vary according to the function of the yard and the nature of the traffic handled, but usually the problem will assume, as in dock-work, two aspects :—

i. Isolated and heavy lifts of machine parts, steel-work, logs, etc.

ii. A constant flow of bulk material and general stores suitable for handling in loads not exceeding 30 cwt.

Means must be found to meet this differentiation of work in the most economical manner.

2 From the point of view of power, mobile cranes may be classified as :—

i. Hand.
ii. Steam.
iii. Electric and petrol-electric, or heavy oil.

Hand cranes are slow, cumbersome and comparatively immobile. Modern practice tends to favour the use of some variant of electric power rather than steam, particular points in its favour being its suitability for intermittent operation without delay in raising steam, and without consuming power while idle. Electric power cannot compare with steam in its capacity to take overloads.

3. For heavy lifts a " Goliath " crane is usually employed in railway yards as shown on Pl. **133**. In this type of crane the whole bridge travels up and down the rail and road tracks which it spans, enabling the transference of heavy loads between road and rail vehicles to be effected without shunting. The movement of Goliath cranes up and down a yard is, however, very slow, and their great weight consumes an excessive amount of electrical power; three motors are required for the motions of lifting, travelling and traversing; and independent hoisting drums should be fitted for lifting light and heavy loads respectively. As the proper use for a Goliath crane is for lifting very heavy loads only, it will usually be found that a mobile luffing jib crane, travelling on a raised track, will meet all normal military requirements on active service, and will perform the work more economically.

4. For general work in a store depot or yard, undoubtedly the most suitable type of appliance is a runabout crane on wheels or tracks. If it is mounted on tracks, the necessity for providing roads or special runways may be avoided. The primary virtue of such cranes is mobility; unlike fixed or railway cranes, the area of their operation is practically

unlimited, and the delay of bringing wagons under a fixed crane and the incidental shunting will be saved by their use. These cranes can move at four to five miles an hour, but are not designed to travel far under their own power. Any work beyond their capacity can probably be concentrated without difficulty under a Goliath or fixed crane. Pl. **134**, Fig. 1, shows a type manufactured by Messrs. Ransomes and Rapier, Ltd. Its performance, and that of similar types of different capacity, are indicated in the following table :—

TABLE T.—PARTICULARS OF MOBILE CRANES

Details.	1-ton.	2-ton.	3½-ton.
(1)	(2)	(3)	(4)
i. Wheelbase	5 ft. 6 in.	6 ft. 9 in.	8 ft. 7½ in.
ii. Overall length ...	7 ft. 6 in.	10 ft. 6 in.	12 ft. 9 in.
iii. Weight of crane in working order	3·8 tons	5½ tons	7¾ tons
iv. Maximum load ...	1 ton	2 tons	3½ tons.
at radius (measured from fulcrum point)	10 ft.	10 ft. 6in.	10 ft. 6 in.
at radius (clear from front of truck) ...	6 ft. 3 in.	6 ft.	5 ft. 3 in.
v. Maximum radius ...	10 ft.	15 ft. (10 ft. 6 in. clear)	17 ft. 6 in. (12 ft. 3 in. clear)
with load	—	1¼ tons	1¾ tons
vi. Maximum height of lift (at minimum radius)	13 ft. 6 in.	18 ft. 6 in.	20 ft.
vii. Minimum headway for transit	10 ft.	12 ft.	13 ft.

Note.—The 3½-ton machine can be supplied with a special snatch block for occasional lifts of five tons.

5. The crane is operated by electric motors taking current from a dynamo driven by a petrol or high speed oil engine. The chassis carries the source of power, the operating motors and the gearing. It is mounted on a fixed 2-wheel axle in front, and at the rear on a 2-wheel articulated castor, which is the driving and steering member, and adapts itself to any unevenness of the ground.

Stability is secured by the jib being always at right angles to the axis of the front wheels; if the crane is called on to lift a weight greater than its capacity at that radius, the tail of the crane will simply lift without raising the load. The controls have been rendered fool-proof by the provision of limit switches for the hoisting and derricking motions, which prevent overwinding and excessive movement of the jib in either direction.

6. Pl. **134**, Fig. 2, shows a steam runabout crane mounted on endless tracks, which will take loads up to five tons.

191. Light railways, tramways and trucks

1. Light railways or tramways may be used in the field in three ways :—

i. As a forward link in the chain of transportation; this is outside the scope of this book.

ii. In constructional work as a means of moving material along definite lines, *e.g.* for removing spoil, etc.

iii. In workshops and depots, for sorting or moving stores, etc.

In the two latter cases they are called tramways.

Their value in the third case is mainly in temporary work, or for dealing with stores, such as ammunition, which do not require special floors for stacking; or for handling material which moves generally in one direction, as in workshops; or on a direct run from the manufacturing shop to the stacking area.

In store yards and depots which are to be in use for some time for the storage of perishable goods, and where the lines of traffic are constantly crossing and reversing, it will usually be more economical to use tramways only as a temporary measure, and to replace them, in those cases where depot working cannot be conducted entirely with the broad gauge system, as soon as possible by concrete or tarmac runways and the railway trucks by electric or motor trucks.

2. A suitable type of tramway is the 24-in. gauge, with 20-lb. rails clipped to steel sleepers at 3-ft. spacing. This track is built up on site with the exception of the turnouts, crossings and turn-tables, which are normally supplied ready built up.

Turnouts must be described as right hand or left hand according to the direction in which the curved roads deviate from the straight. Portable turnouts, which can be superimposed on the permanent track, are very useful where it is desired to take off a temporary branch without disturbing main line traffic.

For mechanical traction the turnouts must be fitted with weighted switch levers.

The lay-out must depend on the locality and nature of the work to be performed, but the track, etc., may have to be ordered in advance. As an indication of what may be required the actual supplies per mile of track to all theatres of war during the Great War were approximately :—

6 right-hand turnouts.

6 left-hand turnouts.

1 locomotive.

Rolling stock—16 axles (capacity about 20 to 25 tons).

The minimum radius of curves is about 40 ft. for temporary work at low speeds, or 80 ft. for permanent lines.

3. 20 h.p. petrol locomotives are probably the most suitable at present for temporary and depot work, but are likely to be replaced in the near future by high speed heavy oil engines.

The performance of the 20 h.p. locomotive should approximate to the following—loads hauled in tons in addition to its own weight.

In low gear on level	80 tons.
In low gear on 1/20 incline	12 ,,
In high gear on level	40 ,,
In high gear on 1/20 incline	4 ,,

Normal speed eight miles an hour, and weight four tons.

Other commercial types of petrol and paraffin locomotives are as follows :—

8 h.p.	Weight,	3 tons.	Load hauled,	40 tons	in low gear	on level.	
16 ,,	,,	3½ ,,	,, ,,	50	,,	,,	,,
25 ,,	,,	4 ,,	,, ,,	85	,,	,,	,,
35 ,,	,,	6½ ,,	,, ,,	140	,,	,,	,,

For permanent depot work, electric locomotives may be substituted where electric power is available.

Electric traction is in such work cheaper than other types, and is noiseless, clean and easily handled.

4. The use of the battery locomotive avoids the complication and expense of the electrification of tracks, etc., whether by trolley wire or third rail, a difficult problem in a " yard "; it is also desirable in working in buildings or in confined work, as in tunnels, etc., where contamination by engine exhausts forbids I.C. engines, and animal traction is undesirable.

Battery locomotives are self-contained, free from smell or fumes, and very easily handled. They can haul 10 to 15 tons on a narrow ill-laid track at speeds up to 10 miles an hour.

If specially ordered the batteries can be obtained contained in steel receptacles, which roll on or off the chassis very rapidly, so that an exhausted battery can be replaced in about three minutes. Spare batteries should be available, which can be charged while the locomotive is in use, and thus a full day's work can be obtained from every locomotive. The life of a battery is short, probably not more than two years under active service conditions, and maintenance is heavy. Against this, charging can be done at night when the station load is small.

5. Bogie wagons are obtainable, but are not likely to be required in depot work except for unusual loads. They can carry about seven tons. For normal depot work, 4-wheeled

box or open platform wagons will generally be used, carrying two tons each. Side-tip steel wagons of normal capacity of 27 cu. ft. are useful on construction work.

6. In all cases the operation of such tramways, to be economical, requires systematic organization and control of traffic movement, loading and unloading. Where direction of movement and precedence of traffic is involved, the use of trucks which do not need rails should be considered, and, where sheds require concrete floors and must be connected by permanent roads, concrete or tarmac roads could be laid down, and all internal traffic carried on road trucks. The use of rapid hardening or aluminous cement will obviate the delay in the setting of the concrete.

Such internal road transport should either take the form of road trains drawn by a petrol or electric battery locomotive, or of independent battery trucks.

7. Battery trucks can carry up to ten times the load of hand barrows, and are faster, and safer on rough ground.

A 2-ton truck is driven by a 3 h.p. motor and 20 cells, at a speed of about five miles an hour, and its weight is about 25 cwt.

It can also be fitted with an elevating platform, which enables it to be used for stacking.

Spare batteries will enable all trucks to be used while the spares are being charged; this can be done by a generator lorry or a small independent set, or from a switchboard in the garage.

192. Overhead travelling cranes

1. Overhead travelling cranes may be required in large workshops in the base or on the line of communication (Sec. **165**). They will usually require to be operated by power, but in some cases small hand operated cranes may fulfil requirements.

These should not be used for spans over 40 ft. or loads exceeding five tons; but for occasional work up to these limits they can adequately take the place of power operated cranes.

The normal installation would consist of a single girder crane, operated from the floor level by hanging chains. The pull on a hand chain should not exceed 40 lb. a man, and the hoisting gear should be fitted with a self-sustaining brake, which requires to be released by the operator before the load can be lowered, but which is inoperative while hoisting.

2. Overhead power cranes.—

i. By far the most useful type is the electric travelling crane. Under active service conditions the standard type

which may require to be provided is the 2-ton travelling crane working over a 36-ft. span.

The motions provided for are hoisting, traversing and travelling, and separate motors should be fitted for each of these.

ii. The particulars of an ordinary commercial 2-ton travelling crane for use in standard workshop sheds are as follows :—

Size. 2 ton.
Span. 36 ft.
Head room. 5 ft. 6 in.
End clearance. 7 in.
Wheel base. 8 ft. 6 in.
Maximum pressure per wheel. 3 tons.
Weight of crane. 7·3 tons.
Speeds in ft. a minute. Hoist, 20.
Traverse, 100.
Travel, 300.
Falls of rope. 2.

A typical overhead travelling crane is illustrated diagrammatically on Pl. **135**.

iii. In field workshops where standard sheds fitted for travelling cranes are not available, the crane is best carried on a structure independent of the main building. A pair of H beams form an economical set of girders, but the width of the flange of one girder must not be less than $\frac{1}{60}$ of the crane span. These beams should be supported at suitable intervals by stanchions, or brick or concrete pillars.

iv. For the crane itself the most economical construction is the trapezoidal single web girder, as indicated on Pl. **135**, with lattice auxiliary connected to the main girder by horizontal and diagonal bracing. The platform and travelling gear are supported by bearers between the main and auxiliary girders.

v. The power required to travel the crane can be taken at 60 to 70 lb. a ton.

The power for hoisting can be determined from the following :—

$$\text{h.p. of motor} = \frac{\text{foot tons per min.}}{10} = 4 \text{ h.p. for a 2-ton crane.}$$

vi. The cranes should be fitted with two brakes, for hoisting and travelling.

CHAPTER XXXIV

AERIAL ROPEWAYS

193. General

1. Aerial ropeways are chiefly valuable where other means of transport are impracticable owing to unsuitable ground. They also form an economical and efficient means of carrying small loads across any ground by the most direct route. They are not designed to pick up traffic between the terminals, but can be utilized to deposit material by tipping at any determined point on their route. Their main disadvantage lies in a comparatively limited carrying capacity. Supplies on ropeways can be robbed easily both by allies and enemies, and protection may be required where a ropeway crosses points accessible to either, *e.g.* the roofs of houses, etc.

2. From a military point of view their good points under such conditions are :—

i. Simplicity and portability.
ii. Elasticity of design and capacity (within reason).
iii. Moderate cost of installation and maintenance.
iv. Low cost of operation.
v. Low visibility and comparative invulnerability. On the other hand, one lucky hit may cut the rope, and incapacitate the whole system.
vi. Reliability and comparative immunity from interference by weather.
vii. A minimum of skilled labour required for operation.

In mountainous country or marshland, or in a district intersected by numerous waterways, a ropeway can be constructed much more easily and expeditiously than a road or light railway.

3. Ropeways are of two types :—

i. The monocable, in which a single endless rope both supports and moves the load.
ii. The bicable, in which the load is supported on a fixed rope and moved by a separate hauling rope.

Adapted to these systems are :—

(*a*) The fixed or non-detachable clip system ; on the single rope type.
(*b*) The Jig-back or to-and-fro system, which is applicable to both.

The relative capacities of the various systems are indicated in the following table :—

TABLE U.—COMPARATIVE ROPEWAY CAPACITIES

System.	Maximum length.	Average gradient.	Maximum gradient.	Maximum hourly capacity.	Maximum individual load.
(1)	(2)	(3)	(4)	(5)	(6)
Monocable	40 to 45 miles	1 in 2·5	1 in 1	200 tons	1·5 tons
Fixed clip	1·5 miles	1 in 2	1 in 1	8 tons	4 cwt.
Bicable	20 to 25 miles	1 in 2	1 in 1	250 tons	2 tons
To-and-fro	1 mile	—	1 in $1\frac{1}{2}$	—	17 tons

4. The monocable, being the simpler and more portable, is the more generally useful for military purposes, but its capacity is at present limited to about 150 tons an hour, and it cannot cope with a steeper average gradient than 1 in $2\frac{1}{2}$.

The bicable system requires less power to run, and is cheaper to operate. Neither of these conditions is of great importance on active service. But it also has a capacity rising to 200 tons or more an hour and can negotiate average slopes of 1 in 2 (its cables may be in parts therefore as steep as 1 in 1).

The fixed clip single rope system is suitable for light duty over short distances, when it is especially suitable for automatic tipping or for electric control. It is simple, easily installed and adaptable to steep grades. As both rope and carriers are in constant motion, loading must be done by hand or by means of a hopper travelling at the same speed, which is usually hung from overhead rails at the terminal station.

The to-and-fro system is suitable for short distances, especially where individual loads are high in relation to the capacity.

Double track is used in this system for heavy loads and passenger service.

If a larger capacity than 200 tons an hour is required, duplicating a ropeway is preferable to increasing either the number of loads or the rope speed.

Generally, the monocable should be selected for light loads and small spans in fairly level country, and the bicable double track system for steep inclines, long spans, heavy loads or passenger carrying. The monocable is cheaper and easier to transport, erect and maintain ; there is only one rope and, if that breaks, less damage is likely to occur. The lubrication and inspection of this rope can be readily effected at the terminals.

Passenger cable ways frequently have a third or "safety" rope, which is only used in emergency.

A simple use of the double track to-and-fro system is that in which the ropeway is actuated by gravity, the loaded carrier in descending hauling up the empty or less-heavily loaded carrier from below. The two carriers are connected by the hauling rope, which passes through a braking mechanism at the top, from which one man can control the speed.

194. Design and lay-out

1. The basis of the design is the unit load to be carried. This is normally about 1 per cent. of the hourly capacity of the system, *i.e.* 10 cwt. for a delivery of 50 tons an hour (a single load of 12½ cwt. could be carried on such a ropeway by supporting it on two carriers).

Alternatively, if it is required to carry 1-ton loads, the design of the ropeway will be for a delivery of 100 tons an hour and, if less than that is delivered, fewer carriers will be used and the system will not work at its full economical capacity.

2. The question of dividing the ropeway into sections (Sec. **195**) must then be considered before its lay-out can be surveyed.

The location of the terminals will be governed principally by facility of transfer to or from some other link in the transportation system.

In plan the straightest route between the terminals is to be preferred, as each angle necessitates an expensive angle station; if, however, for power reasons the ropeway is to be divided into sections, changes of direction can be economically and simply effected at the section junctions; the change of direction at any one standard should not exceed 1 degree.

Vertically, the change of grade at any standard may be as much as 8 degrees, but, if the line includes a high hill with concave slopes or other similar obstacles, the gradient of the rope can only be reduced by using either high trestles or long spans: the latter is more usual, but leads either to increased sag, which increases the gradient again, or increased tension, which means larger ropes, heavier trestles, pulleys and tension weights, and stronger terminals, all of which increase the cost and time of erection.

Terminals, angle stations and section junctions should be at as low a height as possible for convenience of loading, etc., and in order to reduce their cost and time of erection.

3. When the direction has been decided, the line must be surveyed and accurately pegged out with a theodolite and a

large scale longitudinal section taken. The curve of the rope may be obtained from the formula

$$\text{Dip} = L^2\ W/8T$$

where L=span, W=weight per unit length, and T=tension.

If this is set out on paper on the longitudinal section the most suitable positions and heights for the supporting standards can be determined.

195. Power

1. The power required to run a ropeway is considerably less than that required by any other means of land transport. When traversing undulating ground the loads on the up grades are balanced by those on the down grades, so that only a constant average is required in place of the maximum power which is necessary with other means of transport to surmount the maximum grade. Where the grade in favour of the loads is sufficient a ropeway will work automatically. It has been found in practice that a ropeway having a capacity of 40 tons an hour running with the grade, and having a length of one mile, will just work automatically on a grade of 1 in 24.

2. The length of section will depend primarily on the difference in level between the section terminals. A ropeway carrying equal loads up and down a 10 per cent. grade will theoretically require no more than the power necessary to overcome friction, as in the case of a dead level line. It is the increase of rope tension which restricts the length of section; so that, while it may be easy to run a 4-mile section on the level, on a 10 per cent. grade the length could not exceed two miles without seriously reducing the factor of safety of the rope.

3. The peak load in starting a ropeway is always high on account of the relatively heavy mass to be put into motion; and it will take about 30 per cent. more power during the first two weeks than afterwards when bearings have been run in. It is, therefore, often advantageous to introduce a second or slow-speed gear on long ropeways to obviate the necessity of installing a motor, which would, once the system is run in, normally be working at only 60 per cent. of its economic output.

The driving power may be determined from the formula :—

$$\text{Power in ft. lb.} = \Big\{(W_1 \times W_2 \times \mu_1 \times \frac{N}{2} \times V) + (W \times 2L \times \mu_2 \times V) + (2R \times V) + F\Big\} \pm \text{Theoretical Power}$$

Where W_1=Wt. of full carrier; W_2=weight of empty carrier; μ_1=coefficient of friction for carriers; N=total number of

carriers on line ; V=velocity in ft. per min. ; W=weight per ft. of traction rope ; L=length of line in ft. ; μ_2=coefficient of friction of traction rope ; R=no. of supporting pulleys ; F=power required for station friction.

The first four factors give the power necessary to overcome friction. The theoretical power required or developed depends on whether the loads are ascending or descending.

The factor for station friction varies for different lines, but 0·02 of the total weight of moving parts on the stations $\times$ the speed gives a good mean.

4. Power may be supplied by steam or, preferably, internal combustion engines, or by electric motors. The plant for semi-permanent lines will normally be laid down on concrete foundations: but for portable lines may be anchored on timber framing and weighted down with sandbags or boulders. For convenience of supervision and cheaper cost of running it is generally preferable to have the motors of two adjacent sections together ; thus in a line of two sections, the tensioning arrangements might be located at the terminal stations, while the motors working both sections would be situated at the intermediate station.

In a single-section line it is preferable to have the motor, if possible, at the higher station in order to secure direct haulage on the rope.

196. Stations

1. Terminal stations provide power, anchorage, tensioning gear and loading and unloading arrangements.

2. In the bicable system the carrier usually rides off the track cable on to a shunt rail (Pl. **136,** Fig. 1). The track cables can then be anchored, with or without an interposed tackle, by means of a windlass or, preferably, by means of a hanging weight (Pl. **136,** Figs. 2 and 3). This latter method keeps the tension constant and permits the cables to sag and adjust themselves to loads. Track ropes should be anchored at the upper end, and tensioned at the lower.

Unless the carriers are permanently fixed to the moving rope by locking clips, they are released on arrival at the station and led by the shunt rail to the loading or unloading site and then on round to the return side of the cable. Power can then be applied to the moving rope through two or more turns round a friction drum or wheel. Power should always be applied to the loaded rope.

If the carriers remain fixed to the moving rope, two difficulties occur. First they have to be loaded or unloaded on the move, which may necessitate instantaneous discharge from a hopper, or loading from or into trucks moving above or

below at approximately the same speed, or automatic tipping devices. Secondly, it is not possible to take several turns round the driving drum, and the application of power is, therefore, less efficient.

3. In the monocable system the difficulty lies in tensioning and applying power to the same moving rope, and this is still further complicated if the carriers remain fixed to the rope. Usually, tensioning is done at one terminal and driving at the other.

4. Angle stations are necessary for appreciable changes in direction. They increase both the capital and maintenance cost of the installation, but may be provided with tensioning gear. At these and at junction stations, carriers pass from one line to the other on a shunt rail. Switch rails enable junctions to be made between several converging ropeways.

197. Standards

1. Standards may vary from permanent reinforced concrete towers to temporary portable timber trestles held in position by guys, but they are normally built up of steel sections and stand on concrete foundations. The height depends on the head room required at the centre of the span (*i.e.* on the sag) and on the need for a uniform grade. In horizontal section they may be triangular, or more often rectangular and, if designed in sections of equal height with special steel corner castings, are readily adaptable to all heights and can be rapidly assembled; they should be fitted with steps for climbing.

2. Over level ground the distance between the standards of a monocable may be from 100 to 200 yds.: 400 ft. is a normal figure. With the bicable system, while crossing a valley, spans of 4,000 ft. have been successfully exceeded.

Since the tension in a cable varies with the sag, for the same tension and loads the greater the sag the greater the permissible span.

Increased sag is possible across a valley, but is undesirable over level ground, as it would necessitate increasing the height of the standards.

3. Standards should always be sited on the higher levels so as to economize in their height, to avoid washouts, and, by permitting an increase of sag, and thereby of span, to reduce their number.

Wind pressure must be allowed for in the design of the standards, and guides must be fitted to prevent the ropes being blown sufficiently out of position to foul when a carrier passes.

Various types of standards are shown on Pl. **136**, Figs. 4, 5 and 6.

The hauling rope of a monocable and the track ropes of a bicable should be suspended on pivoted arms which rock to the load and thus reduce wear. Normally they pass over two sheaves on the pivoted arm, but for heavy loads the cables may be supported on four sheaves on each standard (Pl. **136**, Fig. 7).

In the bicable system the so-called fixed ropes move over their intermediate supports, owing to changes in the positions of the loads and in temperature. In order to avoid any overturning movement on the standards, the supports for track ropes must, therefore, be grooved sheaves, rollers or saddles, designed also to offer no resistance to the wheels of the carriers.

The hauling rope is supported by its attachment to the carriers, but brackets with guides and rollers are usually provided on the standards to prevent it dropping too low.

With the monocable the supporting sheaves must revolve, and are usually mounted in pairs on balanced secondary arms, pivoted on the top of the trestle so as to distribute the pressure equally on a series of sheaves.

The introduction of a number of balanced sheaves in series greatly reduces the wear and tear of the rope, and allows of very long spans being employed.

The bearing pulleys are mounted in pairs, and used in sets of 2, 4 and 8, and are made in sizes of 18, 21 and 24 in. in diameter, taking thrusts of 500, 750 and 1,000 lb. respectively.

198. Carriers and clips

1. Carriers may be of any form suitable to the material which is to be handled; some simple forms are illustrated on Pl. **137**.

The wheel base of the carrier carriage should be short. In order to avoid spilling the load on a steep gradient, the carrier should be designed to hang vertically, whatever the tilt on its clip or rollers. In high winds carriers both full and empty are apt to sway laterally and damage the standards or the loads, unless suitable precautions have been taken.

To prevent lateral tipping, the suspended rod should be so bent that the centre of gravity of the load is vertically below the cable.

Passenger carriers are usually supplied with an emergency hand or automatic brake for use in case of excessive speed, in addition to a normal hand brake in the carrier and the brake at the terminal control station installed on all ropeways.

With the monocable running carriages are not required, and all that is necessary is a clip to fix the carriers on to the rope.

In the bicable system the running carriage consists of either a single or a pair of suitably grooved wheels (Pl. **137**, Figs. 1 and 2). Below the carriage and attached to the frame of the carrier is a device to secure the carrier to the hauling rope in the form of either a friction (screw) or a locking (lever) grip.

2. With the monocable typical clips employed are Roe's patent toggle clip and saddle clips.

The former (Pl. **137**, Fig. 3) is capable of sustaining a load at an angle of over 45 degrees, and in theory is the most efficient of all clips actuated by the load, as the whole of the load comes into action for gripping.

The saddle clip (Pl. **137**, Fig. 4) is, however, usually found preferable in practice. In this type the gripping is done by two saddles with inclined sides, one side having a feather projection, which engages in the lay of the rope and is so formed that it disengages on the carrier entering a station without damaging the strands.

In the fixed clip single rope system the carrier is permanently fastened to the rope by means of a spring steel trap (Pl. **137**, Fig. 5), and is so designed that it can pass over trestle sheaves and round terminal stations without becoming detached from the rope.

In the bicable system there are two kinds of carriers in general use ; those with screw grips and those with lever grips.

These again may be subdivided into the over and undertype grips, dependent on whether the hauling rope is attached to the carrier above or below the carrying rope.

The advantages of overtype grip are that it requires a shorter length of station, and is more easily adapted for taking curves in both directions.

The main disadvantage is a tendency to tip the running head on steep gradients, as the traction rope falls outside the wheel base.

A typical screw grip is illustrated in Pl. **137**, Fig. 6, and a locking grip in Figs. 2, 7 and 8 on the same plate.

3. Clips generally must be reliable, should come into action gradually, and should allow of adjustment to take up play. The semi-automatic type should be capable of being actuated automatically by a cam or rail or by hand, as required (" Standard " type). The automatic type is normally actuated by the application of weight, so that, as the load leaves the shunt rail, the clip tightens. Similarly, on arrival the shunt rail takes up the load and the clip automatically loosens (" Ideal " type).

Such friction grips are apt to slip in wet weather and are not reliable with loads over 6 cwt. on slopes steeper than 1 in 3.

A great advantage of them is that, since the rope may be engaged anywhere wear and tear is distributed all along its length. They also allow a varying number of carriers to be attached to the rope and, therefore, meet variations in the traffic. The speed of the rope and the slope of the shunt rails must be adjusted so as to give satisfactory attachment and release of the grip.

Before attachment takes place, the carrier should run by gravity a short distance down the shunt rail so that its movement at the time of attachment reduces the jar. On release, the momentum of the carrier should be sufficient to run it well clear of the moving rope, but should be reduced gradually to bring it to rest at a convenient spot.

In some systems, where steep gradients have to be negotiated, the rope is thickened at intervals by the insertion of an enlarged steel core, or by a sleeve, so as to provide a better grip for the clip (Pl. **138**, Fig. 3).

199. Ropes

1. With the monocable the rope is usually made of steel of an ultimate strength of 80 to 90 tons per sq. in., of Lang's lay, with a specially hard hemp core, and with a factor of safety of 4 or 5. Sometimes wire cored ropes are used, but they do not last as long. The turning pulley at either end should be at least 6 ft. in diameter; that at the return end should be anchored, and that at the driving end adjustable. The hauling rope of a bicable ropeway will be similar. The track ropes normally should be "locked-coil" lay (Pl. **138**, Fig. 1) giving the smoothest possible surface, and are usually of 60-ton steel. They are normally anchored at the driving end with a ring wedge coupling (Pl. **138**, Fig. 4), and tensioned at the other end, and are kept about 7 ft. apart. Moving ropes must have hempen cores; fixed ropes may be wire-cored. 6-strand ropes enable a very smooth long splice to be made for an endless rope.

With lines carrying only a small tonnage per hour, spiral ropes (19 wires for 1 in. diameter and 37 wires for 1½ in. diameter ropes) may be used and are much cheaper (Pl. **138**, Fig. 2).

2. The speed of the hauling rope depends chiefly on the facilities and arrangements at either end for loading or unloading; it is usually between 300 and 400 ft. a minute. This gives 100 ft. between loads for a time interval of 20 seconds, which is seldom reduced.

The life of a properly maintained rope should be about five years. Lubrication of an endless rope is normally by drip feed at the terminals, and of fixed ropes by special

TABLE V.—DIAMETERS OF CARRYING ROPES

Diameter of hauling rope.	Weight of load in cwt.									
	3	4	5	6	8	10	16	20	24	28
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
(1) $\frac{1}{2}$	(2) $\frac{13}{16}$	(3) $\frac{7}{8}$	(4) $\frac{15}{16}$	(5) 1	(6) $1\frac{1}{8}$	(7) $1\frac{3}{16}$	(8) —	(9) —	(10) —	(11) —
$\frac{9}{16}$	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{15}{16}$	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{1}{4}$	—	—	—	—
$\frac{5}{8}$	$\frac{7}{8}$	$\frac{15}{16}$	1	$1\frac{1}{16}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{1}{2}$	—	—	—
$\frac{11}{16}$	$\frac{15}{16}$	$\frac{15}{16}$	$1\frac{1}{16}$	$1\frac{1}{16}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{9}{16}$	—	—	—
$\frac{3}{4}$	$\frac{91}{15}$	$1\frac{1}{16}$	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{5}{16}$	$1\frac{9}{16}$	$1\frac{11}{16}$	$1\frac{13}{16}$	—
$\frac{13}{16}$	—	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{9}{16}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2
$\frac{7}{8}$	—	—	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{5}{16}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2

lubricators at each sheave or by continuous oiling from the carrier rollers.

In the more elaborate bicable installations arrangements are made whereby the track ropes can be periodically moved a few feet so as to spread the wear over a greater length of rope.

3. Laying out the cable must be done with great care, to avoid the weakening caused by putting strain on a " kink." In rough country the cable may have to be unreeled and formed into a connected series of small coils, each of which is loaded on a pack animal.

4. Table V on preceding page, extracted from Kempe's Engineer Handbook, and reproduced by permission of the publishers, gives the diameters of special locked rope for various loads and haulage ropes.

200. Light field ropeways

1. Light monocable ropeways were employed in the field during the Great War. Compared with other methods of transporting material, they are less visible from the air and less liable to interruption by shell fire. As the life of the plant was of relatively small importance compared with portability, these ropeways were designed of the lightest materials consistent with efficiency ; in particular, the weight of station frames was reduced to a minimum by the use of small terminal wheels.

2. The plant was designed for a maximum capacity of about 10 tons an hour, individual loads being 3 cwt. at a spacing of 32 yds. (about 18 seconds) and the rope speed 330 ft. a minute. The petrol engine (14 b.h.p.) for each unit was capable of giving the full capacity of the line up to two miles on the level, and for a proportionately shorter length with an adverse grade.

3. The trestles or standards were erected at intervals of 45 to 50 yds. on level ground, but, where a valley allowed increased dip, they could be put 100 yds. apart, using pair sheave mounts, or 300 yards. apart with quadruple sheaves.

A common type (Pl. **139**, Fig. 1) consisted of a 17-ft. length of 4-in. water-pipe supplied with a cross-piece, adjustable in height, which carried the supporting wheels for the rope. In soft ground the base was secured to a buried cross-beam or iron base-plate ; in rocky ground the head was held by side guys.

Usually trestle wheels were so mounted as to be self-aligning, thus obviating the necessity of erecting the trestles dead in line, and allowing divergence within 2 ft. of the true

centre line. To avoid the possibility of the rope floating, a safety wheel on a balanced spring was introduced for use on trestles in hollows.

4. The terminals of one of these lighter forms of ropeway are shown on Pl. **139**, Fig. 2 (the driving and tension station) and Pl. **139**, Fig. 3 (the return terminal).

Power was transmitted to the driving wheel by a petrol motor cooled by water from a tank placed on top of the station, and utilized as ballast to keep the station down. The whole driving terminal was mounted on rails, and tension was applied by a tail rope passing from the back of the station frame to a winch provided with an anchorage to take the pull of about three tons.

The driving terminal, complete with gear and engine, weighed under 2 tons, and could easily be transported from point to point on a 3-ton lorry. The return terminal weighed only about ½ ton, and, if necessity arose, this could be man-handled. The diameter of the terminal wheel was 4 ft. 6 in., which was consequently the distance apart of the ropes.

5. It was estimated that a mile of ropeway could be put up in a day with a properly trained squad, allowing half a day for the transport to the site and erection of the terminals, and the remainder for the fixing of the rope, etc.

6. The table below gives details of three typical installations, and Appendix XVIII gives details of three examples from actual practice.

TABLE W.—PARTICULARS OF TYPICAL ROPEWAY INSTALLATIONS

	A.	B.	C.
System	Mono	Mono	Bicable
Gradient	Level	1/13 down	—
Capacity	50 t/h	150 t/h	30 t/h
Discharge at terminal	—	—	—
Bucket load, net ...	8½ cwt.	18 cwt. or 26 cwt.	8 cwt.
,, ,, gross ...	12 cwt.	22 cwt.	11 cwt.
No. per hour ...	120	166	75
Time interval ...	30 secs.	21·7 secs.	48 secs.
Rope speed	360 ft./m.	390 ft./m.	300 ft./m.
Bucket distance ...	180 ft.	140 ft.	240 ft.
Maximum span ...	300 ft.	690 ft.	490 ft.
Size rope, haul ...	3¼-in. circ.	4-in.	2-in.
Weight	500 lb./300 ft.	270 lb./100 ft.	—
Sag (approx.) ...	7 ft.	52 ft. loaded	—
Maximum tension ...	17,000 lb.	21,300 lb.	—
Breaking stress ...	34 tons	51·6 tons	—
Factor of safety ...	4½	4½	—
Length	3,300 ft.	8,125 ft.	1,155 ft.
h.p. required ...	12 developed	60	13
h.p. provided ...	20	—	20
Track rope	—	—	4 in.

CHAPTER XXXV

CONSTRUCTIONAL PLANT

201. Excavators.—General

1. Mechanical excavators are of two main types—those with a chain of buckets and those with a single bucket. The former are one-purpose machines requiring skilled manipulation and favourable conditions. They are suitable for digging straight lengths of trench in easy and uniform soil, and are used for clay cutting in brickworks, etc., for which purpose machines can be obtained which will cut either above or below where they are standing. They may also be used in conjunction with a spoil conveyor for raising continuous embankments. (*See also* Military Engineering, Vols. II (Defences), and VIII (Railways).)

2. Single-bucket excavators are more likely to be of use on active service owing to the great variety of work for which they can be used. In the smaller sizes a " Universal " type of excavator can be employed :—

i. as a shovel ;
ii. with a drag-line ;
iii. as a grab.
iv. as a skimmer-scoop ;
v. as a trench excavator ;
vi. as a back-filler ;
vii. as a crane ;
viii. as a pile-driver.

Generally, however, different jibs are required for these various functions, and it may require up to one working day to change the jib of a machine.

3. Single-bucket excavators are rated according to the size of the bucket ; these are normally from $\frac{1}{2}$ to 3 cu. yds. level measure, although buckets are made of $\frac{1}{3}$ cu. yd. and up to 10 cu. yds. capacity. The larger sizes of buckets are only fitted to specially designed machines, which are not convertible so readily to other work.

The size of bucket suitable for a particular work may depend on the material in which it is to work and the output of that material required, the depth of the cut, the wagon capacity if wagons are to be filled, or the position where the spoil is to be dumped.

The length of the jib also varies with each machine.

4. In order to avoid special precautions to ensure lateral stability, the machine for general purposes should be of the "full circle" type, in which not only the jib, but also the "body" machinery and superstructure, can revolve completely on the "chassis," enabling work to be carried out at any vertical plane independent of the position of the wheels or track. "Half circle" machines have certain advantages for special work, but for military purposes these are outweighed by the disadvantages.

With equal bucket capacity the full circle type gives greater height of cut, 50 per cent. greater width of reach, a larger levelled floor area, and a greater radius for dumping; its cycle speed may be slower, but this disadvantage is counterbalanced by its greater general handiness.

5. A track mounting is the most generally useful, as it can be self-propelling, wastes less time in closing up to the work and can travel moderate distances by road. For long distances it should be railed on a truck.

A model is also on the market mounted on a 6-wheel heavy lorry capable of a road speed of 15 m.p.h.

Even on a fairly hard soil a timber platform or track is desirable. Two parallel tracks of half railway sleepers, each of which can be moved by one man, are suitable.

6. **Steam drive** is the best, owing to its simple control, great flexibility, and the fact that, since speed automatically varies inversely with the load, stalling causes no damage.

Steam plant is the least liable to damage through unskilled handling. The supply of water and coal may present difficulties in some cases.

Internal combustion drive is more suitable for small sizes; not being as flexible as steam and driving through clutches, it needs greater skill in operating and a higher standard of maintenance. Its use, however, may be valuable when water is scarce or fuel supply difficult, and eliminates the delays in starting and the boiler wash-outs needed by steam engines. Its output over a long period should equal that of a steam driven machine.

Crude oil engines are obtainable even with machines of small bucket capacity, and for immediate requirements may be more readily available. The supply of petrol or paraffin may, however, present fewer difficulties than that of heavy oil.

Electric drive may combine the advantages of both the above, but special control gear is necessary to avoid damage from heavy overloading. An electric drive, when available, means the minimum time off for repairs. For moderate sized

machines, A.C. with slip-ring motors is the best system ; for the large sizes, D.C. drive through series-wound motors is better.

Compressed air drive is suitable for work in tunnels, as it ventilates and does not pollute the air.

7. The motions in all cases are :—

digging,
rotating,
travelling and
dumping,

of which the first two will always require power, and the third also in self-propelling machines.

202. The mechanical shovel

1. The **mechanical shovel** or **navvy** is the commonest type of machine, and that which gives the greatest output. The cut is made radially upwards away from the foot of the machine, which must, therefore, stand on the floor of the excavation and move forward as the work progresses. The digging action is a combination of hoisting the bucket up the face of the cut and "racking" it out in the line of the jib to control the thickness of the cut. It, therefore, requires a rigid bucket arm able to withstand constant vibration as well as twisting and reversal of stress, which cause bolts and rivets to loosen and a tendency to crystallize the steel. Bolts on the jib yoke block and bucket arm should be inspected and tightened frequently.

2. The jib is movable and is lowered for travelling, but for digging is held at a constant angle, 40 to 60 degrees, normally 45 degrees. Any one machine can be fitted with varying lengths of jib and varying sizes of bucket. The combination of the shortest jib with the largest bucket will give the greatest output in the most difficult material. A longer jib goes with a smaller bucket and can only be used with an easier soil. It is, however, used at a steeper angle, thus not increasing the jib head radius, but giving greater cutting and dumping height at the expense of speed and output. The average maximum height for a 2-cu. yd. shovel is about 35 ft.

3. The larger machines have greater cutting power and are, therefore, necessary for refractory material. Machines of normal bucket capacity of 1 cu. yd. or less should not be used for hard rocky soil, or stoppages and repairs will become frequent.

The buckets for cutting hard soil should be provided with renewable teeth of high carbon or other alloy steel.

4. **Output** depends on many factors, but, as regards the machine, on the digging speed, which may vary from 80 to 120 ft. a minute, and on the slewing speed, which may vary from 1 to 6 revolutions a minute.

The average cycle under good conditions should take from ½ to 1 minute, varying with the soil and with the size of the machine, and assuming that no delay takes place with dumping. A speed of six cuts a minute has been achieved.

With a good average driver the output per 8-hour day should make a ½-cu. yd. machine equivalent to about 40 European labourers (digging only), and a 2-cu. yd. machine about equal to 100, in sandy soils. The machine has a greater advantage in the harder soils.

The output per day in medium clay may be taken as averaging 300 cu. yds. for a ½-yd. bucket, 600 cu. yds. for a 1-yd. bucket and 1,000 cu. yds. for a 2-yd. bucket.

The fuel consumption will vary :—

if coal, between 3 and 6 lb. a cu. yd.
if oil, between 0·25 and 0·35 lb. a cu. yd.

A ½-yd. shovel will consume about 1½ gals. of petrol or 1 gal. of crude oil an hour, a 2-yard shovel about 4 gals. of crude oil an hour.

If driven electrically, the consumption will vary between 0·35 and 0·6 units a cu. yd.

203. Drag-line excavator

1. The drag-line excavator scoops soil up towards itself from below. It, therefore, stands above its work and moves backwards as it progresses. It is suitable for employment in cases where a shovel cannot be used, *i.e.* for excavating in water or where the excavated floor is not hard enough for a shovel to stand on, for digging trenches and narrow cuttings with insufficient width for a shovel to revolve in, and for building railway embankments from above.

It is not so efficient as a shovel, which should, therefore, be preferred, especially in heavier soils.

2. The digging is effected by a combination of hauling in the bucket and hoisting it to control the thickness of the cut. Hauling in the bucket should not transversely stress the jib, which can, therefore, be longer and lighter, giving a greater width and depth of cut and a greater radius or height for dumping than the shovel.

3. Dumping into wagons requires accuracy and can only take place at jib head radius, but, if the spoil is to be heaped loosely, the bucket can be thrown about 25 per cent. farther.

With practice the bucket can also be thrown for digging a considerable distance beyond the jib head.

4. The angle of the jib may vary from 25 degrees to 50 degrees, and depends largely upon where the bucket is to be discharged. The length of the jib may vary from 20 ft. to 160 ft., according to the size of machine and bucket.

If the machine is not self-propelling, it can haul itself forward on rollers by using the bucket as an anchor.

5. **Output.**—The drag-line excavator works slightly faster than the shovel, but, as it usually takes a longer cut, the cycle is about the same (Sec. **202**). In wet soil, or when dumping into small wagons, a deduction of 25 per cent. should be made.

For ordinary digging the driver requires no more skill than for a shovel, and damage is less likely, but greater skill is required for levelling a surface or trimming banks; with a skilful driver, however, no further hand trimming will be required.

204. The grab or clam-shell

1. The grab or clam-shell is normally used for picking up, loading or unloading loose material in a heap, but it is also suitable for digging in a confined space where there is not even room to run a drag-line, as in sinking wells, caissons or foundations. It can also be used at depths too great for a drag-line, the limiting depth for which may be taken to be half the length of the jib, to, say, 30 ft. on the average.

2. The bucket may be of the **grab** or **clam-shell** type, made in two segments and provided with teeth for dealing with heavy material; of the **orange-peel** type with 3 or 4 curved triangular blades for cutting wet clay; or of the **grapple** type for removing boulders. An essential point is that the bucket should not roll over even if lowered on to a 45-degree slope.

3. The closing of the bucket is the first action caused by the tension on the hoist rope. Vertical movement only starts when the bucket is shut.

The bucket is opened for dumping in various ways. In the 2-line type, the bucket is supported on a second rope, the hoist rope is paid off and the weight of the contents of the bucket opens it. This is the most general type and can be worked with drag-line equipment.

Grabs with a single line are suitable for attaching to a crane or shovel without special attachments, but the bucket is apt to spin unless precautions are taken. Dumping may be effected by the release of a trigger by a trip rope worked by

the driver or a man on the ground, or automatically by easing off the hoist rope when the bucket has been hauled up to and caught in a ring. This latter method means that discharge takes place at a fixed height; the height of the ring, however, is adjustable.

4. The efficiency of a grab depends largely on the design of the bucket. A light bucket is more economical, but it must be heavy enough to penetrate the material to be dug; in practice it is never lighter than the volume of material which it lifts, and the harder the material the heavier the bucket must be. It should also be designed to give a good digging leverage, with no projections close to the edges of the bucket to prevent penetration.

The span of the bucket when open should be $1\frac{1}{2}$ times its width.

The hoist speed of a grab is greater than the digging speed of the other types, but its output depends entirely on the work on which it is employed.

5. **Trench digging** may be done by a multiple-bucket excavator, or by drag-line equipment, or with a shovel, modified in one of two ways, viz :—

i. With the use of an extra long bucket arm, which, when vertical, enables digging to be carried out below the level on which the machine stands. This position is, however, inefficient for power, and is not suitable for heavy material. As the machine spans the trench in part, it is also unsuitable if the sides are likely to cave in.

ii. By the use of a back-acting shovel, which is more satisfactory, as the machine can stand on undisturbed ground.

6. The **skimmer-scoop** is another modification of the shovel, in which the bucket travels along a horizontal, or nearly horizontal, arm for levelling or trimming a surface. Its reach is much more limited than that of the drag-line, which is often more efficient for this purpose, but the scoop can tackle much harder material, and is even used satisfactorily for breaking up a road surface. It can work to one side, and deposit spoil on either side at will. It should not be used for depths greater than 2 ft.

Back-filling is normally done by drag-line, or by a blade mounted behind a shovel, which scrapes the soil back into the trench.

7. Pl. **140** shows the Ruston "Universal" excavator in six typical operations.

205. Organization of work

1. The output of a digger depends more on the organization of the work than on the handling of the machine, unless the material excavated can be discharged anywhere on a spoil bank. When dumping has to be into wagons, the latter should be as large as possible, preferably five or six times the capacity of the bucket.

If small wagons have to be used, a hopper will facilitate quick dumping and avoid spilling, and if provided with some storage will prevent the excavator having to wait for empty wagons. Hoppers can be readily designed to fill more than one wagon, but are not satisfactory if the spoil is wet.

2. The shunting of the trucks can take place while the excavator has stopped work, *e.g.* when moving or relaying floor. These stoppages, however, will not occur to the same extent if the machine is self propelling and especially if it is fitted with track: shunting must, in such cases, be reduced to the minimum.

Shunting takes the greatest time where the trucks have to be run into a dead end cutting; two sidings, each long enough for a complete train, is an improvement, but the best plan is to avoid shunting by using a loop track, if necessary on the surface above the cutting. If this is not feasible, it may be economical to make a cutting of several cuts, the sidings being run through the previous cut.

3. The lay-out of tracks should always be worked out on paper first and arrangements made for extending them to keep pace with the progress of the excavation.

Night work can be carried out using flood lamps on the excavator above the driver's head, focussed on the bucket and the full depth of its cut.

Conveyors and elevators can be of great assistance in getting the maximum output from an excavator.

The arrangements for water and fuel supply for the digger, and also for the locomotive hauling the spoil wagons, require careful consideration and organization from the **start** of the work. Haphazard arrangements in this respect may result in long delays and considerable slowing up of the work.

4. **Operating hints :—**

i. Keep the machine level.
ii. Slight undercutting with a shovel may prove economical, but care must be taken to avoid damage due to serious falls.
iii. Do not continue cutting when the bucket is full.
iv. Keep close up to the face so as not to work unnecessarily at the maximum reach.
v. Avoid jerks.

vi. Do not slew until the bucket is clear of the cut.
vii. Start and finish slewing and travelling gradually.
viii. Avoid dropping spoil from a height into the wagons.
ix. Maintain the engine in good condition and keep spare parts at hand.
x. Make the operator responsible for running repairs.
xi. Keep the tracks neither too loose nor too tight.
xii. Keep spare teeth at hand and ensure that all teeth are kept sharp; blunt teeth greatly decrease output.

206. Stone crushers

1. Stone crushers are made with a wide range of output varying from 200 tons to 1½ tons an hour. Active service conditions, however, will always require a stone crusher to be reasonably easy to handle, and in many cases to be mobile or portable.

For this reason outputs of crushers for use in the field will never exceed 30 tons an hour, and will usually range between 6 and 12 tons an hour.

2. There are three types of stone-breaking machines in general use, viz. jaw-crushers, gyratory crushers and roller crushers.

Of these the jaw-crusher type is perhaps the most common, and the most suitable for general use in the field.

In essence the great majority of jaw-crushers are constructed on the same plan.

i. The stone is crushed between a fixed jawplate and a pivoted movable one, the latter being actuated by a powerful double toggle movement communicated to it from the driving pulley through an eccentric shaft and a pitman.
ii. The jaws can be adjusted to break up the stone to any required size by sliding wedge-shaped blocks, which affect the position of the toggle block, and thus cause a corresponding alteration in the distance apart of the crusher jaws.
iii. The jaws are lined with removable and reversible cheek faces of manganese steel, there being usually two pieces on the fixed jaw and one on the swinging jaw.
iv. The working parts are contained in a massive cast iron or steel body, fixed on a travelling carriage in the smaller sizes, and with a base plate fitted with holding down bolts in the larger ones.
v. They are fitted with flywheels and driving pulleys for belt drive from an independent power unit.

This may be either internal combustion, steam engine or electric motor.

vi. Steam has the disadvantage of requiring both fuel and water, and is readily spotted from the air at a distance. Stone crushing, however, is liable to create very sudden and heavy overloads, particularly if the stone is very hard and oversize blocks are fed in to the jaws. If steam plant is not installed, it is advisable to have electric motors or I.C. plant of capacity at least 50 per cent. above that recommended by the makers of crushers for any particular crusher plant; otherwise the output will not be maintained and breakdowns will be frequent.

vii. For outputs of over 10 to 12 tons an hour for each machine it will usually be advisable to obtain crushers with bedplates and to fix them on to solid timber foundations.

With crushers on travelling carriages the wheels should be wedged securely to prevent any movement.

3. Pl. **141** gives a section through a typical crusher.

4. Crushers are classified by the size of the opening or mouth in the top of the body through which the stone is fed to the jaws, and which governs the output of broken stone.

5. **Output.**—The actual output will vary with the hardness of the stone, but Table X gives approximate details and performances for hard limestone broken to a $2\frac{1}{2}$-in. ring of typical modern crushers in commercial production of sizes suitable for use in the field.

6.—i. Screens for separating the crushed stone into various grades are supplied as an adjunct to stone crushers and are often of great utility.

ii. In view of their weight and the extra power required to drive them, it is doubtful if they would be installed on active service in any but large quarries served by a broad gauge railway.

iii. They can be driven in a variety of ways, *e.g.* with bevel gearing, with sprocket wheels and chain, with spur gearing, or in any other way that circumstances may require.

iv. Screens can be supplied in a large range of sizes, both as regards diameter and length, but in general, the following will be found suitable with portable plants.

Size of crusher mouth. in.	Size of screen.	Screen speed. revs. a min.	Approx. weight. cwts.	Perforations, inches.
14 × 6	6ft. × 1ft 9in. diam.	$22\frac{1}{2}$	10	$\frac{5}{16}$, $1\frac{1}{8}$, $1\frac{3}{4}$, $2\frac{3}{4}$
14 × 9	6–8ft × 2ft. ,,	$22\frac{1}{2}$	13–15	do.
16 × 9	6–10ft. × 2ft. ,,	$22\frac{1}{2}$	13–15	do.
20 × 8	8–10ft × 2–2ft. 3in.	$22\frac{1}{2}$	13–15	do.
20 × 10	8–12ft × 2–2ft 6in.	$22\frac{1}{2}$	20	do.

TABLE X.—PARTICULARS OF COMMERCIAL STONE CRUSHERS

Size of mouth. in.	Output an hour. Tons.	Weight of heaviest piece. cwt.	Total weight.		External dimensions (Approximate only).			Size of driving pulley. in.	Belt width. in.	Revs. a min.	b.h.p. required (makers' figures).
			Steel body.	Cast iron.	Length.	Breadth.	Height.				
(1)	(2)	(3)	(4)	(5)	(6) ft. in.	(7) ft. in.	(8) ft. in.	(9)	(10)	(11)	(12)
10× 6	3 to 5	17	34	45	5 6	3 4	3 7	20 to 24 ×4½ to 6	4	250 to 280	6 to 9
12×8 to 9	4½ to 6	20	43	65	5 10	4 0	4 0	20 to 24 ×4½ to 6	4	do.	9 to 10
16×9½ to 10	7 to 10	41	84	100	6 3	4 9	4 7	30× 6	5	do.	18
20× 6 to 8	9 to 11	48	108	115	6 4	5 6	5 0	30 to 36 ×6 to 7	6	do.	23
20×10	10 to 12	57·5	124	150	7 4	5 6	5 3	30 to 36 ×7	6	do.	25
24×13 to 14	15 to 18	106	214	269	8 6	7 0	6 0	36 to 42 ×10	9	do.	30
24×18 to 19	16 to 22	135	250	300	9 0	7 6	7 2	36 to 42 ×10½ to 12	10	do.	35 to 45
30×12	20 to 22	142	296	350–80	9 0	8 0	7 5	42×12	10	do.	55
30×18	20 to 25	154	321	387–400	9 6	8 0	7 10	42×12	10	do.	55 to 60

v. With fixed crushers larger screens may be usefully employed, ranging from 30 to 36 in. in diameter, and from 10 to 16 ft. in length and up to 30 cwt. in weight. It is unlikely that screens larger than this would ever be required in the field.

Screens are usually divided into four sections, each with different sized perforations ranging from 2¾ or 2½ in. to ¾ or ⅝ in. diameter.

7. Granulators.—

i. In certain cases there may be a special demand for chippings, beyond the capacity of the plant and screens normally installed in a quarry. This may be more especially the case with a concrete products factory, where large quantities of finely broken stone may be required for various concrete products.

In such cases the installation of granulators may be justified. These are small stone crushers with jaws set close together, and work on the same principle as crushers of larger sizes.

ii. The granulators should always work in conjunction with screens, as accurate grading of the stone is nearly always necessary, and a considerable quantity of stone dust may often require elimination.

iii. Typical market sizes of granulators and their performances are given in the following table :—

TABLE Y.—PARTICULARS OF COMMERCIAL GRANULATORS

Size of mouth. (1)	Output tons an hour. (2)	Size of pulley. (3)	b.h.p. required. (4)	Size of screen. (5)
in. in. in.		in. in. in.		ft. ft. in.
9 to 10 × 4	1½	18 × 4½	6 to 7	6 × 1 9
12 × 4	2	20 to 24 × 5½	9 to 12	6 × 2 3
12 × 6	2½	20 × 6	9 to 15	6 × 2 3
16 × 6	3 to 4	24 × 6	16	6 × 2 6
10 × 6 to 7	4 to 5½	30 × 6	23	6 × 2 6
24 × 7	6½	30 × 9	25	8 × 3 0
30 × 7	8	36 × 10	30	12 × 3 0

8. Special types of portable combined crushers and screens, fitted in some cases with automatic elevators, are also manufactured; but these are more particularly for employment at the roadside, and are not likely to be of any great utility under active service conditions.

207. Concrete mixers

1. Wherever any considerable amount of concrete work is required the employment of a concrete mixer will give large savings in labour and time, and will ensure a more regular output with a more even quality of concrete.

2. Although there are a large number of different types of mixers in the market, they do not differ to any marked extent in main principle.

A concrete mixer consists in essence of a drum of varying size, mounted on tripod or similar brackets, rotated by gearing at varying speeds, and capable of tilting either while still rotated or when at rest.

3. **Drums.**—Drums are of various shapes, but the cone or double cone are the more common, and this shape helps to retain the mix in the drum while it is rotating.

Drums may be entirely clear inside or fitted with fixed blades or baffles to ensure a more rapid and intimate admixture of the ingredients.

An alternative but less common arrangement is for the drum to remain stationary, and the mixing to be done by revolving paddles.

4. **Feed.**—The drum is usually fed from a spout, and discharges by tilting over and emptying either through another spout or down a chute into the collecting receptacle.

A feeding skip is frequently attached to the mixer, which when loaded is raised by the driving machinery to discharge into the feeding spout.

The feeding skip is designed for use as a gauging box, the capacity being exactly that of the mixer.

In some types a feeding hopper is installed, discharging direct into the drum, and of a capacity equal to that of the drum.

With these mixers, delivery of the ingredients should be at hopper level, either from a bank or by elevator.

A water tank fitted with regulating valve and gauge glass is fitted in a convenient position to discharge into the drum, and is controlled automatically or by hand.

5. **Power transmission.**—Power is transmitted from the main driving shaft by mitre gear to a spur bevel gear on a cross shaft, which meshes with the gear encircling the drum. Alternatively it can be by bevel gear drive direct with the drum ring, although this latter system is perhaps not quite such sound practice.

The source of power may be either steam or petrol engine, or electric motor.

6. **Carriage.**—The most useful type of mixer for general use is fitted with wheels and can easily be moved from place to place.

Larger types are usually mounted on skids, which rest on a platform or on the ground.

Travelling platforms on wheels or trucks are supplied with these for moving by road.

7. **Hints on working.**—

i. Set the machine level.

ii. Oil or grease all bearings thoroughly.

iii. Although the materials can be fed in any order into the machine, it is usually preferable to put in some water (25 to 50 per cent.) first, then sand, cement, stone, and the remainder of the water. In this way the drum is washed clean before each batch is mixed and loss of cement from dusting is prevented.

iv. Wash out the drum before shutting down. If it does not clean with water only add a little crushed stone.

v. See that the machine is kept in thorough repair. Certain working parts have a heavy duty and get hard wear, *e.g.* upper edge rollers on the discharge side, bevel gear teeth, etc., and should be replaced before they get badly worn.

8. Average typical performances of market types of mixers are given in the following table :—

TABLE Z.—PARTICULARS OF CONCRETE MIXERS

Batch capacity. cu. ft.	Output an hour. cu. yds.	Drum revs. a min.	h.p. required.	Average weight on skids. cwt.
(1)	(2)	(3)	(4)	(5)
2 to 3	2·5 to 3·5	20 to 24	2 to 3	10 to 15
5 to 6	6 to 9	18 to 20	3 to 4	15 to 20
9 to 12	12 to 18	15 to 18	5 to 6	24 to 40
15 to 18	20 to 36	13 to 15	10	44 to 54
30	36 to 60	11 to 12	15 to 18	80 to 110
60	80 to 120	9 to 12	25 to 35	160

The outputs should approximate to the higher figure given in column 2 with practice.

The weights differ very considerably with various types of machine and source of power. The figures given in column (5) are average ones. The time for mixing also varies from 30 to 45 secs. with small machines to over 1½ minutes with the larger ones.

9. Typical concrete mixer details are illustrated on Pl. **142.**

CHAPTER XXXVI

WORK FOR THE ROYAL AIR FORCE

208. General considerations

1. The works organization of the R.A.F. is on a civilian basis. Hence, in any theatre of war outside the United Kingdom, except in those cases where the R.A.F. will be operating from its permanent bases, the works services required will normally be carried out by military engineers. (F.S.R., Vol. I, 1930, Sec. 87, 7.)

2. Whilst the general accommodation of the R.A.F. will be on lines similar to that of the Army, as already described in this volume, there are certain particular requirements which require special consideration.

These are principally :—

i. Landing grounds—either ordinary landing grounds with no buildings except petrol supply and caretaker's hut, or aerodromes, *i.e.* landing grounds with technical buildings attached.

ii. Hangars.

iii. Workshops and stores in aircraft depots.

Although in all these cases the provision will be normally of a temporary nature, in certain instances work may approximate to peace time practice, particularly in the cases of those aerodromes and installations which will in all probability remain in the same position throughout the campaign.

209. Landing grounds and aerodromes

1. Although the selection of aerodromes is primarily a matter for the R.A.F., it is most desirable that engineer officers who may have to carry out any work required on them should know the principles on which this selection is made.

Under active service conditions, aerodromes can be classified broadly as :—

Class (*a*). Those in use against a civilized enemy.

Class (*b*). Those in use against an uncivilized enemy.

i. **Class** (*a*).—These will generally be more liable to air attack than to ground attack. Many of them will be situated well back from the front line, but those required for army co-operation squadrons should be chosen as near to divisional headquarters as possible. It is very difficult to find landing ground sites exactly where they are required, but every effort should be made to select sites in positions difficult to locate from the air, especially with relation to conspicuous features, such as rivers and other water surfaces, well defined woods, road intersections, railway junctions, or any objects readily identified from the air, the proximity of which should be avoided as far as possible.

The lay-out of hangars and buildings will also require special consideration (Sec. **213**).

ii. **Class** (*b*).—These will be liable to ground attack, and possibilities of good ground defence will be of relatively greater importance than invisibility from the air.

2. The most important part of an aerodrome is the landing ground, and the factors requiring consideration in the selection of a suitable landing ground are :—

i. Dimensions and shape.
ii. Surface, slope and drainage.
iii. Air approaches and general surroundings.
iv. Meteorological conditions.
v. Communications, water supply, etc.

The choice between equally convenient landing grounds may be made on purely military grounds, but war conditions will usually demand the selection of grounds which are either fit for immediate use or can be made so at a relatively small cost in time and labour.

It will seldom be possible or profitable to undertake extensive improvements which may take several months to carry out, more especially as work on a landing ground surface nearly always involves the putting out of action of that landing ground for the duration of the work.

3. **Dimensions and shape.**—Irregularly shaped landing grounds, even when well marked, are confusing to a pilot. The best shape is a square or rectangle.

The normal minimum dimensions of a landing ground are 500 yds. in any direction. If the ground is more than 3,000 ft. above mean sea level, or if it is likely to be used for night flying, the minimum dimensions are 600 yds., and if over 6,000 ft. they should be 700 yds.

If the air approaches are bad, the above dimensions should be increased in accordance with para. 5, below.

If a rectangular ground is impracticable, a L- or T-shaped ground may be chosen, with arms of the above dimensions in length, and normally not less than 250 yds. in width. If the ground is for temporary use only, and the above dimensions cannot be obtained, the largest dimension must be in the direction of the prevailing wind, and the clearing of the air approaches must be specially arranged.

4. **Surface, slope and drainage.**—The surface of a landing ground should be free from furrows, ditches, small banks and any sudden change in the degree of hardness of the soil or in the slope of the ground. Stony ground causes punctures, and damages tail-skids and air screws. Soft sand or soggy patches, especially if they alternate with harder ground, tend to overturn aircraft taking off or landing.

In India, for instance, black cotton soil is impossible in rainy weather and full of dangerous cracks and holes in dry weather.

All these surfaces should be avoided if possible.

Where there is considerable rain, the best land to choose is permanent pasture with porous surface soil and well drained sub-soil.

All grounds should be capable of standing up to the weights of heavy aircraft.

Slope and drainage may be considered together. The best slope is one sufficient to run off storm water without the formation of ruts. This varies with the type of soil and nature of the surface, but no slope should exceed 1 in 50. A steep slope tends to cut into ruts, and makes a landing difficult if the wind is uphill.

Very flat ground, unless the soil is very porous, or the rainfall negligible, tends to become water-logged.

Gently undulating ground is permissible, but sudden or marked changes of inclination are dangerous.

Soggy ground can often be improved, if time permits, by suitable drainage work, and in many cases catch water drains will have to be made on one or more sides of a landing ground. Where ground is liable to flood, it may also be necessary to build protective bunds on one or more sides.

These and any drainage ditches should always be large enough to be visible from the air, and no drain or bank should be nearer than 30 yds. to the edge of the ground.

Areas subject to ground mist or fog should be avoided where possible.

5. **Air approaches and general surroundings.**—The air approaches to a landing ground are most important. In

the case of a ground on a plateau with one side bordering on a steep descent, or when there is a ditch along one side, a pilot invariably flies in high and lands well inside the edge, to ensure avoiding the obstacle. Trees and buildings in proximity to the ground are serious obstacles.

It may be assumed that a pilot clearing a tree or other obstruction will first touch the ground at a point at an angle of 1 in 15 with the horizontal, and all ground between that point and the obstruction is useless, *i.e.* if a tree is 40 ft. high the pilot touches the ground 200 yds. away. Obstructions are equally dangerous to a pilot in taking off. If, therefore, such obstructions are continuous on any side of a landing ground, the edge of the ground must be pushed out the required distance, or the size of the landing ground increased by the same amount. If the above are impossible the only remedy is to remove the obstruction, or to make flying gaps in it. Thus trees can be cut down and gaps for machines to fly through created. The minimum width for a gap is 60 yds.; normally it should be 200 yds.

Telegraph and other wires are invisible from the air, and they should be buried or removed from the vicinity of the landing ground and placed either behind visible obstructions, or, for safety, at such a distance that aircraft descending at 1 in 30 on to the edge of the landing ground will clear the wires.

The vicinity of steep hills is dangerous and should be avoided, but a site on high-lying ground is advantageous as ensuring more freedom from fog and from drainage difficulties and usually less obstruction in the air approaches.

Open, fairly level ground round a landing ground, especially in the direction of the normal wind, is an advantage, as it makes forced landings safer, if the engine cuts out as the machine leaves the ground.

6. **Local meteorological conditions.**—It is necessary to study the liability of an area to rainfall, flood, fog, mist, sandstorms, high wind, squalls, etc., which in excess are adverse factors in choosing a site.

7. **Communications, water supply, etc.**—Squadron and other formation aerodromes will normally only require good road access, but rail access will always be essential for an aircraft depot with its workshops and stores.

The usual water supply and camping facilities, as laid down in Part I and II of this volume, will be necessary.

8. **Landing ground report.**—A landing ground report will always have to be prepared when a new landing ground is selected.

This will be in the following form :—

Landing ground report form.—

i. Map reference.

ii. Position.—

- (*a*) County or province.
- (*b*) Latitude.
- (*c*) Longitude.
- (*d*) Nearest town, village, etc., and distance and direction from it.
- (*e*) Local magnetic variation.

iii. Description.—

- (*a*) Dimensions in various directions.
- (*b*) Height above mean sea level.
- (*c*) Nature of surface—*e.g.* whether sandy, clay, stony, etc. If sandy, whether loose sand drifts with wind and collects in lumps round scrub or grass.
- (*d*) Conditions of surface—*e.g.* whether there is a tendency to rut; existence of boulders, bushes, grass, etc.
- (*e*) Slope and drainage, and condition during rains—*e.g.* general slope of ground, whether natural drainage could be improved, etc.
- (*f*) Possibilities of extension and work necessary—*e.g.* possibilities of extension in any direction, whether excavation or filling required, especially of nullahs, retaining walls, removal of trees, roads, buildings, etc.
- (*g*) Nature of air approaches, north, south, east and west.—Detail all wires, trees, buildings, hills, ditches, bunds, etc., within 200 yds. of the boundaries, giving their height and distances from the nearest edge of the ground.
- (*h*) Nature of surrounding country.
- (*i*) Time and labour required for making the ground, and of any suggested extension, *e.g.* clearing and making surface fit for landing, retaining walls, catchwater drains, clearing gaps or obstacles to air approaches, regulation markings (Sec. **211**), approach road, etc.

iv. Taking over or acquisition.—

(*a*) Classification as regards ownership or control of ground, *e.g.* whether Government Department, local authorities or private ownership.

(*b*) Willingness of owner, authority or department to part with the land.

(*c*) Cost of acquisition ; compensation to be paid, if any, etc.

v. Accommodation.—

(*a*) Camp sites.

(*b*) Water supply.

(*c*) Communications.

vi. Meteorological conditions.—

(*a*) Prevailing winds.

(*b*) Season for rain, dust-storms, etc.

(*c*) Local mists, fogs, etc.

(*d*) Other meteorological data.

210. Levelling

1. Mounds or ditches on the landing ground should be levelled, and on grass landing grounds returfed. Any depressions caused by the grubbing and removal of internal fences are best filled up with soil. Ditches should be piped before being filled up. Small depressions on a heavy landing ground are best filled with cinders. In the case of permanent grounds bad areas must be put out of action, turf removed and old or new turf replaced. The cinders help drainage.

2. If the selected site is under ridge and furrow it can be dealt with in various ways :—

i. If the turf is good and the depressions slight, it will be sufficient to fill in the furrows with ashes mixed with loam an inch or two at a time, so as to allow the grass to grow through, and to roll judiciously. This has the advantage of leaving the turf undisturbed, and does not interfere seriously with the natural drainage.

ii. With more pronounced ridges and furrows, the turf should be lifted and the soil skimmed off the ridges and levelled into the furrows, and the turf then replaced and rolled. In filling the hollows the addition of a small proportion of ashes is sometimes beneficial.

iii. An alternative to this is to plough up the whole of the ridge and furrow land, harrow several times as required, reseed and roll.

As the ground cannot be brought into regular use until a good turf has been formed this method is not likely to be applicable to war conditions.

3. As a guide to the general smoothness and firmness of the ground, it should be possible to drive a car at 35 miles an hour on any part of the landing ground without inconvenience to the occupants, or alternatively it should be possible to drive a fully loaded 3-ton pneumatic-tyred lorry slowly over it without the wheels sinking in.

211. Normal marking of landing grounds

1. The following rules give the normal marking of landing grounds, and should be thoroughly understood by all engineer officers. In war it may be necessary to reduce these markings to a minimum in the case of advanced grounds. Bad ground, however, should always be shown by a small cross of strips while flying is in progress.

Normal landing ground markings are required :—

i. to demarcate land taken up for a landing ground ;
ii. to call the attention of a pilot to the landing ground ;
iii. to show clearly to all incoming pilots the exact area on which it is safe to land.

2. Permanent markings are as follows :—

i. To demarcate land taken up for a landing ground :—
Small brick pillars or wooden posts should be set up at every corner of the area set aside for the landing ground. They should be whitewashed.

Their object is to define the area on the ground with a view to stopping encroachment.

They also serve in desert countries to show pilots on the ground the extent of the landing ground, and thus assist them in taking off.

ii. To call the attention of the pilot to the landing ground :—

A circle should be made of 50 yds. diameter of broken brick or metal, consolidated and white-washed, chalk or white concrete.

The width should be 4 ft., and the depth after consolidation, 6 in. The top of the consolidated metal should be flush with the ground and should conform to the slope, if any, of the ground. There should be no step or hump between any portion of the circle and the ground.

The circle is always sited in the best area for landing.

iii. To show to incoming pilots the exact area of safe landing :—

This is carried out by corner angle flats and, when necessary, bad ground markings.

(*a*) Corner angle flats consist of strips of stone or brick metal, consolidated and whitewashed, chalk or white concrete. The width should be 4 ft., and depth after consolidation, 6 in. From every corner of the actual landing area strips 40 ft. by 4 ft. are laid in the exact direction of the next corner. The pilot knows that he can land safely inside the angle flats. (Pl. **143,** Fig. 1.)

(*b*) Bad ground markings are required for marking portions of the landing ground which are temporarily unfit for use.

i. When the area is small it is marked with a cross only. This can be made by whitewashing the ground (after shaving off any grass), or by pegging down white cloth. The arms of the cross should be 30 ft. long by 3 ft. wide. (Pl. **143,** Fig. 3.)

ii. If the area is considerable, it can be marked out as in Pl. **143,** Figs. 2 and 4. In Fig. 2 by moving the angle flats the bad ground is cut out. In Fig. 4 by placing a cross in the centre of the bad ground and angle flats round the edges the pilot recognizes the area to be avoided. Temporary angle flats are whitewashed and similar in construction to the crosses.

3. Temporary landing grounds markings consist of :—

i. Circles.

ii. Corner flats.

iii. Bad ground markings.

These are temporary markings only, and the ground is merely cleared of grass and whitewashed.

The dimensions are the same as for permanent markings.

212. Maintenance of landing grounds

1. The chief problem in connection with a landing ground is the maintenance of the surface in good condition. This is of the utmost importance, and a ground which is indifferently maintained may be the cause of serious injury to pilot or passengers and of considerable damage to a valuable aeroplane. The natural conditions which go to make a good landing ground, viz. comparative levelness of surface and freedom from obstruction, are those which often cause considerable difficulties in maintaining a dry and hard landing surface, and the problem is further accentuated by the ground having to stand a user which in its nature is constantly breaking up the surface, and tends to interfere with the natural drainage.

2. Whereas aeroplanes will land on or take off from any portion of a landing ground, traffic is concentrated in front of the hangars or places of assembly ; and it is these areas which get badly cut up. The seriousness of the damage depends largely on the nature of the soil. With dry sandy soils the churning up creates dust but not mud, and the simplest remedy is to restore the surface by rolling or hand ramming, spraying with water as required. With clayey soils, an absolute quagmire is created in wet weather, which may not dry out for weeks and which is a danger to men and aircraft.

3. With temporary landing grounds, even in the latter case, it will seldom be possible or necessary to do more than fill in the furrows caused by the tail skids, and roll or ram in by hand the displaced soil or turf at frequent intervals ; but in exceptional cases the duration of occupancy may justify more permanent measures. The chief consideration is that the work should be quick and cheap, and easily maintained.

In very exceptional cases it may be possible to provide concrete or tar-macadam aprons outside the hangars, but even in such cases the same problems soon occur immediately in front of the aprons themselves.

A comparatively cheap and reasonably efficient process is to treat the soil with an oil of a suitable grade.

Where this is done, it will be necessary to provide drainage to take away the storm water from the treated surfaces ; and this is best done by means of French drains, cut after the oiling is completed.

An adequate drain is particularly important at the junction between the oiled and unoiled surfaces.

4. The best method of oiling in any particular case will depend on the nature of the soil, and methods are described below for three typical soils :—

i. A clay soil overlying a chalk subsoil.

ii. A wet clay surface.

iii. A loam and sand surface.

In each case there must be a thorough mixing of the oil with the soil, as otherwise pot-holes and surface drag will occur, and the process must be carried to a sufficient depth, dependent on the soil, but never less than 4 in., to ensure that tail-skids of aircraft do not plough through the oiled skin.

5. With a clay soil overlying a chalk subsoil, the process is briefly as follows :—

i. Excavate and lay aside the top surface to a depth of 4 in., in strips 10 yds. by 3 yds., beginning at one end of the area to be treated, and working progressively through to the other.

ii. Break up the under soil in situ to a depth not exceeding 4 in., and as small as possible. Treat with an approved stable bituminous emulsion, diluted with an equal quantity of water, by mixing with garden forks at the rate of 16 gals. of emulsion and 16 gals. of water to every 30 sq. yds.

Even distribution of the emulsion should be obtained by pouring it through a baffle attached to a watering can.

iii. Even out this bottom layer by raking to the natural grading.

iv. Replace the top 4-in. layer, broken down as fine as possible, and treat as already described with a mixture of emulsion and water at the rate of 38 gals. of emulsion and 28 gals. of water to every 30 sq. yds.

If the weather has been very dry 2 gals. of kerosene should be added as a flux.

v. Each area of 30 sq. yds. should be left for 24 hours, before blinding with fine chippings (granite) and spraying with emulsion at the rate of 6 gals. of emulsion mixed with 18 gals. of water to every 30 sq. yds.

vi. As soon as the surface is free from tackiness hand roll for preliminary consolidation.

vii. Power rolling should then be carried out with a 30 cwt. roller, beginning at one end and running straight

through as fast as possible, and without stopping on the treated area. Rolling should continue at intervals until the area is reasonably consolidated, when the speed may be gradually reduced, and a heavier roller introduced, if required.

viii. Work must only be carried out in dry weather, and tarpaulins must be used to cover up partly completed areas if the weather is showery.

ix. A variation of this process is the premix method, which should be used where the soil is sandy, as it gives a more even distribution of the bitumen. This cannot be used with solid clay.

In this process, the soil is excavated to a depth of 8 in., and broken up into as small particles as possible. It is then measured into an ordinary concrete mixer, of from 3 to 4 cu. ft. capacity, and equal quantities of emulsion and water are added at the rate of $\frac{1}{2}$ to $\frac{3}{8}$ gals. of each per cu. ft. of soil (a stable emulsion similar to Terolas is suitable for this).

The mixture, when thoroughly incorporated, is then laid direct to full thickness, allowance being made for consolidation of about one-third of the full thickness.

Rolling is done first by light hand roller, followed when sufficiently firm by a $2\frac{1}{2}$-ton roller. The surface is then finished off with a dressing of a mixture of emulsion and water on the scale of $\frac{1}{4}$ gal. of each per sq. yd., followed by a blinding coat of $\frac{1}{4}$-in. chippings rolled in with the $2\frac{1}{2}$-ton roller, and finished off with a heavier one, if necessary.

6. With a wet clay surface, preliminary burning of the clay to form a suitable clinker for mixing with the bituminous emulsion is necessary, and the process is briefly as follows :—

i. Strip off all vegetation, and remove to assist in clay burning operations.

ii. Excavate over the area to a depth of 12 in., and deposit in heaps for clay burning.

iii. The clay should be burnt to a degree approximating to calcination for production of ballast for concrete.

The fire should be started with brushwood, which is then covered over with a layer of clay lumps, over which fine coal is scattered in layers. As the clay is burnt more is added and the process repeated.

The fire should not be allowed to burn through to the outside of the heap.

iv. The burned ballast is then screened through a $\frac{1}{2}$-in. mesh screen, and the coarse and fine ballast stored in separate heaps. Flints and large stones should also be removed and stacked separately.

v. The flints and large stones (if any) are first laid in the excavated area to form a bottom bed not exceeding 4 in. thick, followed by the coarse ballast, which should be spread, levelled, rolled and consolidated with a 4-ton roller to a depth of 9 in.

vi. The fine ballast is then thoroughly incorporated (by being turned over the requisite number of times) with a mixture of equal quantities of bituminous emulsion and water at the rate of $1\frac{5}{8}$ gals. of each per sq. yd., and replaced over the whole area in one layer of final thickness of 3 in.

vii. This layer is spread, levelled and well rolled to a smooth and even finish, level with the surrounding areas.

7. With a sandy loam and sand surface, the same treatment should be given as for 4. i., but a final dressing of coal tar sprinkled with chippings should be given, in order to prevent the grass growing up through the emulsion treated surface.

8. If any portion of a landing ground becomes unfit for use, the damaged portion must be cut out with bad ground markings, while repairs are being carried out.

9. Other points needing attention are the following :—

i. Apart from rain damage, trouble may be caused by drifting sand and by ruts and holes caused by local traffic or cattle.

ii. Rain damage can be reduced by efficient drainage, including catchwater drains outside the ground. The circle also requires watching to ensure that the ground in its vicinity does not wear away.

iii. Drifting sand is very troublesome. In some grounds a storm of rain will start grass growing, and the sand is blown against the grass, forming dunes. The same will sometimes occur with camel-thorn. Such grounds are most dangerous to aircraft, and the only remedy is to pull up the grass or camel-thorn to allow the sand to distribute itself.

iv. It may often be difficult to keep cattle or local traffic off a ground, and after rain they may cause considerable damage, which must be watched for.

v. Markings must be kept white and clear of vegetation. Periodical washing should ensure this, but it may be required at frequent intervals during wet weather.

vi. Grass in the vicinity of buildings should be cut periodically to lessen fire risks, and should be kept down on the landing ground by grazing or cutting those parts most in use.

213. Accommodation on landing grounds

1. The provision of accommodation on landing grounds will vary considerably according to circumstances. In advanced landing grounds liable to air attack, the main consideration is the concealment of the ground as much as possible. Aircraft will either be pegged out in the open at considerable distances apart to minimize damage from bombs, or hidden in neighbouring woods, etc. The construction of stable traverses some 10 ft. high (Pl. **144**) to protect individual aeroplanes will be undertaken as soon as labour can be made available.

These will have to be sited to avoid blocking the air approaches, and the entrances to each stable will have to be carefully watched, while in very wet weather some form of hard track will have to be made for the wheels.

The size of the stable traverse in the plate is approximate, and each aeroplane will have to be dealt with on its merits.

The front straight traverse should overlap the side walls of the stable.

2. It is unlikely that buildings will be constructed on forward landing-grounds, though neighbouring billets in existing buildings will certainly be occupied both for stores, workshops, etc., and as accommodation for men. The most important requirement is good road access, and, if a road can be found round more than one side of the ground, it will facilitate considerably the refuelling and arming of aircraft in their stables with bombs.

3. In the East, and in other countries where heat and sandstorms are to be expected, if the unit is likely to stay some considerable time on a landing ground protection from heat and dust will be required. Hangars in the form of tent-hangars or special collapsible hangars will be sent up from the base to protect aircraft, with a specialist, who with local engineer assistance will arrange for their erection.

Light huts will be built for offices, workshops and stores. The wireless cabin will probably be the most urgent of these. Designs will depend on the material available, but will follow those already indicated in this volume.

4. Petrol supplies on advanced landing grounds will be mobile, *i.e.* either from petrol lorries or trailers, or in cans and drums. Oil will be in drums.

5. Bombs will be stacked as convenient and covered with tarpaulins, with traverses constructed round groups.

Bomb components, pyrotechnics and B.1 bombs will be kept under some form of cover, if possible.

6. Generally speaking, on landing grounds liable to air attack, everything will be scattered and camouflaged as much as possible. On landing grounds not liable to air attack, everything will be concentrated both for convenience and, often, for local defence. When ground defence is required, the accommodation area will be surrounded with a barbed wire apron fence with machine gun posts at the re-entrant corners.

In all cases of accommodation, etc., siting is important, with a view especially to keeping the air approaches clear.

214. Aircraft depots and parks in the theatre of war

1. The extent of the repair work to aircraft which will be carried out in a theatre of war on active service will depend on the nature and extent of the operations and the distance of the theatre of war from a permanent R.A.F. base.

2. Repair work is carried out at an aircraft depot, and, when there is an established depot within reasonable distance of the theatre of war it will be utilized. The heavy wastage of aircraft under war conditions may demand a considerable increase in the equipment and shops of the depot, but any engineer work required will be carried out by the permanent staff of the R.A.F. Works Establishment, and is therefore beyond the scope of this volume.

3. Where the distance is excessive, an advanced repair depot may be required in the zone of operations to carry out overhauls and engine repairs, leaving the heavier work of rebuilding and reassembly of aircraft to the main depot.

It is not possible to lay down any definite size or establishment for an advanced depot of this nature, as it will depend very largely on the strength of the R.A.F. contingent with the army in the field.

In the same way stores would be supplied through an established depot, where one exists; and in the case of a lengthy line of communication, air stores parks on the basis of 1 to 6 squadrons would be established in or near the zone of operations. These parks are mobile store distributing and collecting units, and do not carry out repairs to aircraft or R A.F. M.T. vehicles.

4. In many theatres of war, however, an aircraft depot may have to be established, in which case the following considerations should be borne in mind :—

i. **Site.**—The total area required by the depot is approximately 110 acres, excluding the aerodrome, which should be, if possible, about 800 yds. by 800 yds.

ii. **Lay-out.**—The functions of the depot are the holding and supply of stores, and the repairs, assembly and overhaul of aircraft, and the lay-out must be arranged accordingly.

Rail communication will be required to the aircraft repair section, the engine repair section, the salvage dump and the store sheds.

The lay-out will, however, be governed primarily by the possibility of hostile air attack and the resulting necessity of dispersion, in order to offer less favourable targets.

APPENDIX I

SCHEDULE OF THE SCALE OF ACCOMMODATION ON WHICH BUILDINGS ARE DESIGNED

A. General

1. *Living and general accommodation*

A=essential for standing camps and should be erected even if other accommodation is provided in tents.
B=provided before sleeping accommodation.

Description. (1)	Type plan. (2)	Priority of execution. (3)	Scale: Each officer or man. (4)	Scale: Each hut. (5)	Remarks. (6)
Sleeping huts.	Pl.		f.s.		
C.Os. or matrons	**10**	—	120	—	Exclusive of passages. Additional 60 f.s. for every 10 officers for servants' cleaning room.
Officers or nurses	**10**	—	60	—	
Warrant officers...	—	—	50	—	Separate bunks or cubicles if possible.
N.C.Os. and men	**15**	—	36	—	If dining rooms are provided. Each man to have at least 4 ft. wall space.
Accessories.					
Canteens	—	—	3	—	Excluding serjeants' mess members.
Institutes	—	—	9	—	Excluding serjeants' mess members. Requires special sanction in the theatre of war.

Cookhouses	14	B	—	400 f.s. and 1 to 2 f.s. for each man	Minimum 600 f.s. Includes scullery and stores.
Cooking shelters, officers ...	19	A	2	—	Minimum 100 f.s.
Cooking shelters, other ranks	19	A	½	—	Minimum 100 f.s.
Detention rooms	16	B	—	300 f.s.	For every 1,000 men.
Dining rooms	12	B	6	—	—
Drying rooms	13	A	—	400 f.s.	Up to 1,200 men.
Guard rooms	16	B	—	400 f.s.	For every 1,000 men.
Incinerators	42, 43	A	—	—	As required.
Medical inspection rooms and detention wards	60	—	—	—	To be sanctioned by competent authority. Plans to be approved by medical authority.
Messes—					
Officers	10	B	50 to 120	—	Including mess-room, ante-room, kitchen, pantry, larder, store and waiters.
Nurses					
Serjeants	11	B	40 to 60	—	Including mess-room, reading room, kitchen, liquor store, larder, store and beer cellar.
Offices—					
C.Os.	16	B	—	700 f.s.	Including clerks' room.
Company, battery, squadron, etc. ...	15	B	—	120 f.s.	—
Shops	17	—	—	200 f.s. each	Provided only when specially sanctioned.
Stores	15, 17	B	1½ to 2	—	Including quarter-master's office.
Wash-ups	10	B	—	1 sink for every 75 men	Near dining huts and cookhouses.

A. General—*continued*

2. *Latrines and Urinals*

Description. (1)	Type plan. (2)	Priority of execution. (3)	Scale of seats and urinals, per cent. (4)	Remarks. (5)
Officers	Pl.	A	15	—
Nursing sisters and women		A	10	Closets
W.Os. and N.C.Os. and men		A	5	1 seat in 12 for W.Os. and N.C.Os.
Convalescent depot patients		A	5	—
Military prisoners	13	A	5	15 per cent. if men are marched to latrines in sections.
Prisoners of war		A	5	—
Coloured labour		A	5	—
Urinals		A	3	—

NOTE.—Approximately 20 f.s. allowed for each seat, including urinals.

3. *Ablution Places*

Description. (1)	Type plan. (2)	Priority of execution. (3)	Scale of basins, per cent. (4)	Remarks. (5)
Officers	Pl.	A	12	—
Nursing sisters and women		A	15	Each a separate single compartment.
W.Os. and N.C.Os. and men		A	12	—
Convalescent depot patients		A	12	—
Military prisoners	13, 18	A	12	24 per cent. if men are marched to ablution places in sections.
Prisoners of war		A	12	—
Coloured labour		A	12	—

NOTE.—2 f.r. of double bench for each 2 basins; 12 to 14 f.s. each basin. Lean-to of 40 f.s. for boiler where required.

4. *Baths*

Description. (1)	Type plan. (2)	Priority of execution. (3)	Scale of Baths, per cent. (4)	Scale of Slipper or shower, per cent. (5)	Scale of Shower if with steam baths, per cent. (6)	Scale of Area f.s. (7)	Remarks. (8)
	Pl.						
Personnel.							
Officers	13, 18 46	B	5	—	—	—	Bathrooms only provided where officers are not in sleeping huts.
Nursing sisters and women		B	5	—	—	—	
W. and N.C.Os. and men		A or B	—	1	$\frac{1}{2}$	—	
Convalescent depot patients		A or B	—	1	$\frac{1}{2}$	—	
Military prisoners		A or B	—	1	$\frac{1}{2}$	—	
Accessories.							
Steam chamber for steam bath	13, 18 46	B	—	—	—	25	For each 100 men.
Dressing room for steam bath		B	—	—	—	75	For each 100 men.
Shower		A or B	—	—	—	22	
Dressing room for each shower		A or B	—	—	—	22	Except for steam baths.
Slipper		B	—	—	—	33	—
Boiler house		B	—	—	—	65 90	Up to 1,000 men. Above 1,000 men.

B. Hospitals.

Description. (1)	Type plan. (2)	Area each patient. (3)	Area. (4)	Patients, per cent. (5)	Remarks. (6)
	Pl.	f.s.	f.s.		
Ablution places	13, 64	—	—	6	Basins.
Administrative block	59	—	3,000 approx.	—	For general hospital. To contain C.Os.' and clerks' offices, dispensary and dispensary store, waiting consulting, matron's and sisters' rooms, registrar's office and orderly office. Plan to be approved by competent medical authority.
Baths	61, 64	—	—	—	Special scale as required. To be sanctioned by competent authority.
Combined operation, X-ray, and laboratory	58	—	—	—	As required. Plan to be approved by competent medical authority.
Cookhouse	14	—	700+2 f.s. for each patient	—	—
Dining room	12	6	—	—	For 25 per cent. of patients (allowing for 2 relays, assuming 50 per cent. confined to their wards).
Disinfector block	64	—	—	—	To contain a receiving and issuing room.
Latrines	13	—	—	2½	Seats.
Mortuary	62	—	—	—	Body chamber to take 6 bodies for each general hospital. To be provided for groups of hospitals, and to contain a receiving room and a postmortem room.
Pack store	60	—	2,000 approx.	—	For general hospital. To contain rifle racks and racks for kit.
Quarter-master's stores	60	—	3,000 approx.	—	For general hospital. For hospital kit, etc., of patients.
Reception room	60	—	3,000 approx.	—	For general hospital.
Urinals	13	—	—	1½	—
Wards	56, 57	50 approx.	—	—	5-ft. wall space for each patient.
Wards, isolation	63, 64	100approx.	—	—	To contain nurses' duty room, range, scullery and linen and bed-pan stores.

C. Animals

Description. (1)	Type plan. (2)	Area each horse. (3)	Area. (4)	Remarks. (5)
	Pl.	f.s.	f.s.	
Chaff - cutter, corn-crusher and engine shed	65	—	—	As required.
Dung pits or platforms	—	—	—	1 for each stable.
Exercising track with crush	68	—	—	As required.
Forage barn and granary	65	—	—	As required. If several days supplies are drawn in bulk, store should be large enough to hold them.
Forge and shoeing shed	65	—	1,700	For 500 horses.
Horse troughs	19 or 66	—	—	1 ft. run double-sided per 6 horses.
Kraals	68	—	—	As required. To be sanctioned by competent authority.
Pharmacy	65	—	400	For 1,000 horses; minimum size 200 f.s.
Stables	65	60	—	Includes rooms for harness and forage.

D. Temporary training camps (Sec. 34 and Pl. 19).

1. Cooking shelters.—
   Officers, Serjeants } 4 feet super per head (minimum, 100 ft. super).
   Men ... 35 feet super per 100 men (minimum, 100 ft. super).
2. Meat safes.—
   6′×2′ 6″×2 6″—one for each cookhouse catering for numbers up to 100 men.
   6′×6′×2′ 9″—one for each cookhouse catering for numbers above 100 men.
3. Wash-up benches.—
   One 9-ft. double-sided bench for each cookhouse catering for numbers up to 100 men.
   Two 9-ft. double-sided benches for each cookhouse catering for numbers above 100 men.
4. Ablution benches.—Two 9-ft. double-sided benches per 100 men—4 taps per bench.

5. Shower baths.—$1\frac{1}{2}$ per cent. of strength of men.

6. Soak pits.—

$4' \times 4' \times 4'$ to $6' \times 6' \times 6'$, *but size depends on soil.*
One for each cookhouse.
One per 18-ft. run of ablution bench.
One per 8 shower baths.

7. Grease traps.—One for each soak pit.

8. Horse troughs.—1-ft. run of double-sided trough per 6 horses.

9. Water storage (*where such storage is considered necessary*).—

One 100-gal. tank for each cookhouse for more than 100 men.
One 50-gal. tank for each cookhouse for 100 men or less.
Two 400-gal. tanks for each infantry battalion, and *pro rata* for other units.
Two 100-gal. tanks for each N.A.A.F.I. canteen for a battalion, and *pro rata* for other units.

10. Incinerators.—One for each battalion or unit, or two for each brigade camp.

11. Latrines.—

Officers ...	20 per cent.
Other Ranks	10 per cent. (portion reserved for warrant officers and serjeants on a scale of 10 per cent.).

12. Urinals.—

Day ...	Officers ...	One 8-ft. length.
	Other Ranks	8-ft. per 100 men (portions reserved for warrant officers and serjeants on a scale of 10 per cent.).
	N.A.A.F.I. canteen—One 4-ft. length.	
Night ...	N.U. bucket system.	

APPENDIX II

SCALES OF ACCOMMODATION

A. Infantry or general base depot for 1,000 men

(*see* Pl. **1**)

Standing camp

Partially hutted

ACCOMMODATION

All ranks.—Tents with tent bottoms.

Officers' and serjeants' messes.—Marquees.

Office.—Tent.

Horses.—Picket lines.

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
	Pl. Fig.		
*Ablution places ...	**13** 1	1,600f.s.	In 2 or 4 blocks as convenient.
*Cleansing station ...	**46** 1	1	Provided if considered necessary.
Cooking shelters for officers	**19**	1	100 f.s.
Cooking shelters, sergeants	**19**	1	100 f.s.
Cooking shelters for rank and file	**19**	400 f.s.	In one or more blocks as convenient.
*Disinfector shed ...	—	1	As required according to type, if cleansing station is not provided.
*Drying room	**13** 3	1	—
*Incinerator shed ...	**10** 7	1	As required according to type.
*Latrines, officers and men	**13** 2	5	1 block for officers, 4 blocks for N.C.Os. and men.

Hutted camp

ACCOMMODATION

Troops.—Tents with tent bottoms.

Staff.—Officers, 1 living hut and mess combined (Pl. **10**, Fig. 4).

N.C.Os. and men, 1 living hut (Pl. **15**, Fig. 1).

Horses.—1 shelter (Pl. **65**, Fig. 4).

Accessories marked * above are provided, and in addition—

A. Infantry or general base depot for 1,000 men—*continued*

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
	Pl. Fig.		
Bath and latrine block, officers	**13** 4	1	—
Cookhouse	**14** 3	1	—
Dining rooms	**12** 2	2	For 75 per cent. of the strength.
General and clothing stores and quartermaster's office	**17** 2	1	—
Guardhouse and offices	**16** 1	1	With barbed wire enclosure.
Medical inspection room and ward	**60** 6	1	As required.
Officers' mess	**10** 3	1	—
Serjeants' mess	**11** 2	1	—
Shops—Tailors, shoemakers and barbers	**17** 1	1	—
Wash-ups	**10** or **14**	4 single or 2 double	

B. Base rest camp

Standing camp—Partially hutted

ACCOMMODATION

All ranks.—Tents with tent bottoms.
Officers' mess.—Marquee with floor, 1 for each battalion.
Officers' mess, staff.—Tent.
N.C.Os. and men's mess, staff.—Tent.
Horses.—Picket lines.

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
	Pl. Fig.		
Ablution places ...	**13** 1	—	—
Cooking shelters, officers	**19**	—	1 for each battalion, 1 for staff, 100 f.s. each.
Cooking shelters, men ...	**19**	—	1 for each battalion, 1 for staff. 100 f.s. minimum.
Drying room	**13** 3	1	For a group of camps as required.
Incinerator shed	**10** 7	1	As required according to type.
Latrines, officers and men	**13** 2	—	1 block for officers. 1 or more blocks for N.C.Os. and men as convenient.

NOTE.—Other accessories in marquees or tents.

B. Base rest camp—*continued*

Hutted camp

ACCOMMODATION

Troops.—Same as above.
Staff.—Officers. / Other ranks. } Living huts with suitable hutted messing arrangements.
Office.—Hut as required.
Horses.—Shelters (Pl. **65**, Fig. 4).
Accessories shown above are provided, and in addition—

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
Ablution places and baths	**13** 5	1	W.Os., N.C.Os. and men of staff.

C. Convalescent camp for 1,000 men

Standing camp—Partially hutted

ACCOMMODATION

All ranks.—Tents with tent bottoms.
Horses.—Picket lines.

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (3)
	Pl. Fig.		
*Ablution places	**13** 1	4	—
*Cleansing station ...	**46**	1	—
Cooking shelter, officers	**19**	1	For officers of staff. 100 f.s.
Cooking shelters, men ...	**19**	4	Enclosed, with fixed apparatus. 100 f.s. each minimum.
*Disinfector shed ...	—	1	As required according to type, if cleansing station is not provided.
*Drying room.	**13** 3	1	—
*Incinerator shed ...	**10** 7	1	As required according to type.
*Latrines	**13** 2	—	1 block for officers. 1 or more blocks for other ranks as convenient.

NOTE.—Other accommodation or accessories in marquees or tents.

A. Infantry or general base depot for 1,000 men—*continued*

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
	Pl. Fig.		
Bath and latrine block, officers	13 4	1	—
Cookhouse	14 3	1	—
Dining rooms	12 2	2	For 75 per cent. of the strength.
General and clothing stores and quartermaster's office	17 2	1	—
Guardhouse and offices	16 1	1	With barbed wire enclosure.
Medical inspection room and ward	60 6	1	As required.
Officers' mess	10 3	1	—
Serjeants' mess	11 2	1	—
Shops—Tailors, shoemakers and barbers	17 1	1	—
Wash-ups	10 or 14	4 single or 2 double	

B. Base rest camp

Standing camp—Partially hutted

ACCOMMODATION

All ranks.—Tents with tent bottoms.
Officers' mess.—Marquee with floor, 1 for each battalion.
Officers' mess, staff.—Tent.
N.C.Os. and men's mess, staff.—Tent.
Horses.—Picket lines.

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
	Pl. Fig.		
Ablution places	13 1	—	—
Cooking shelters, officers	19	—	1 for each battalion, 1 for staff, 100 f.s. each.
Cooking shelters, men ...	19	—	1 for each battalion, 1 for staff. 100 f.s. minimum.
Drying room	13 3	1	For a group of camps as required.
Incinerator shed	10 7	1	As required according to type.
Latrines, officers and men	13 2	—	1 block for officers. 1 or more blocks for N.C.Os. and men as convenient.

NOTE.—Other accessories in marquees or tents.

B. Base rest camp—*continued*

Hutted camp

ACCOMMODATION

Troops.—Same as above.
Staff.—Officers. } Living huts with suitable hutted
Other ranks. } messing arrangements.
Office.—Hut as required.
Horses.—Shelters (Pl. **65**, Fig. 4).

Accessories shown above are provided, and in addition—

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
Ablution places and baths	**13** 5	1	W.Os., N.C.Os. and men of staff.

C. Convalescent camp for 1,000 men

Standing camp—Partially hutted

ACCOMMODATION

All ranks.—Tents with tent bottoms.
Horses.—Picket lines.

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (3)
	Pl. Fig.		
*Ablution places	**13** 1	4	—
*Cleansing station ...	**46**	1	—
Cooking shelter, officers	**19**	1	For officers of staff. 100 f.s.
Cooking shelters, men ...	**19**	4	Enclosed, with fixed apparatus. 100 f.s. each minimum.
*Disinfector shed ...	—	1	As required according to type, if cleansing station is not provided.
*Drying room.	**13** 3	1	—
*Incinerator shed ...	**10** 7	1	As required according to type.
*Latrines	**13** 2	—	1 block for officers. 1 or more blocks for other ranks as convenient.

NOTE.—Other accommodation or accessories in marquees or tents.

C. Convalescent camp for 1,000 men—*continued*

Hutted camp

ACCOMMODATION

Convalescents.—28 living huts (Pl. **15**, Fig. 1) for 66 per cent., remainder in tents with tent bottoms.

Staff.—Officers, 1 living hut with suitable hutted messing arrangements.

Other ranks.—1 living hut (Pl. **15**, Fig. 1).

Horses.—Shelters (Pl. **65**, Fig. 4).

Accessories marked * above are provided, and in addition—

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
	Pl. Fig.		
Barber's shop	—	—	A portion of another hut.
Cookhouse	**14** 3	1	—
Dining rooms	**12** 2	1	For 50 per cent.
General and clothing store, with verandah	**17** 2	1	—
Guard room and offices ...	**16** 1	1	—
Medical inspection room and ward	**60** 6	1	As required.
Serjeants' mess	**11** 2	1	—
Wash-ups	**10** or **14**	1 double or 2 single	—

D. General hospital for 1,200 beds

Based on an establishment of—

Officers	35
Female nursing staff	80
W.Os. and serjeants	27
Rank and file	202
Patients—officers, 120; ,, other ranks, 1,080	1,200

D. General hospital for 1,200 beds—*continued*

Standing (hospital) camp

Partially hutted

Accommodation

Patients.—Marquees (wards).
Staff.—All ranks. Tents with tent bottoms.
Horses.—Picket lines.

Accessories. (1)	Type plan. (2) Pl.	Fig.	No. required. (3)	Remarks. (4)
Patients				
Ablution places, officers	13	1	1	8 basins.
*Ablution places, other ranks	13	1	4	Each 16 basins.
*Combined operation, X-ray, and laboratory	58		1	—
Cooking shelter, officers	61	1	1	—
Cooking shelters, N.C.Os. and men	61	1	4	Enclosed, with fixed apparatus.
Disinfector shed ...	—		1	As required according to type.
Incinerator shed ...	10	7	1	As required according to type.
*Latrines, officers ...	13	2	1	5 seats.
*Latrines, other ranks ...	13	2	4	Each 7 seats.
*Mortuary	62	1	1	For a group of hospitals, to take 6 bodies for each general hospital.
Night duty rooms ...	56	3	5	For nurses. 1 for officer patients and 4 for other rank patients.
Staff				
Ablution places, other ranks	13	1	1	—
*Bath block, female nursing staff	—		—	4 baths. Omit shower and ablution place.
Cooking shelter, officers	19		1	100 f.s.
Cooking shelter, female nursing staff	19		1	160 f.s.
Cooking shelter, N.C.Os. and men	19		1	120 f.s.
*Latrine block, female nursing staff.	—		—	7 separate closets.
*Latrines, officers ...	13	2	1	—
*Latrines, other ranks ...	13	2	1	—

*Note.—Other accessories in marquees or tents.

D. General hospital for 1,200 beds—*continued*

Hutted camp

(*see* Pl. **4**)

ACCOMMODATION

Patients.—Officers, 4 wards (Pl. **57**).
Other ranks.—Ward huts (Pl. **56**), if available; otherwise marquees with boarded floors.
Staff.—Officers, 1 living hut (Pl. **10**, Fig. 1).
Female nursing staff, 3 living huts (Pl. **10**).
Other ranks.—8 living huts (Pl. **15**, Fig. 1).
Horses.—Shelters (Pl. **65**, Fig. 4).
Accessories marked * above are provided, and in addition—

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
Patients	Pl. Fig.		
Administration block ...	**59** 2	1	—
Bath blocks, officers ...	**64** 1	2	6 baths, 2 showers, and ablution places
Baths	**61** 3	4	—
Cookhouse	**14** 2	1	—
Dental surgery	—	1	As required.
Dining room	**12** 1	1	25 per cent. of patients.
Disinfector block ...	**64** 2	1	Less steeping room. 1 large or 2 medium disinfectors.
Disinfector shed ...	—	1	If no fixed disinfectors are available.
General surgical dressing hut	**59** 1	1	—
Incinerator and bed-pan cleaning shed	**61** 2	1	—
Isolation hut	—	1	—
,, ,, attendants	—	1	—
Officers' mess	**10** 3	1	Add 20 ft. to ante-room.
Pack store	**60** 1	1	—
Pack and linen store, officers	**60** 1	1	28 ft. by 50 ft. Less 2 bays. Omit rifle racks.
Quarter-master's store ...	**60** 2	1	—
Reception room	**60** 3	1	—
Staff			
Ablution places and baths, other ranks	**13** 5	1	—
Dining room, other ranks	**12** 1	1	—
Cookhouse, other ranks ...	**14** 5	1	—
Female nursing staff mess	**10** 3	1	With mess room, ante-room and kitchen each 10 ft. longer.
Officers' mess	**10** 3	1	—
Serjeants' mess	**11** 1	1	—

NOTE.—These scales may be followed, as far as is applicable, for other special hospitals.

E. Isolation hospital

If the necessity for the provision of accommodation for special isolation hospitals arises, the following detail, based upon 140 beds, may be taken as a guide :—

Hutted camp

ACCOMMODATION

Officers.—1 living hut (based on Pl. **10**, Fig. 2).

Female nursing staff.—1 living hut (based on Pl. **10**, Fig. 2).

Other ranks.—3 living huts (Pl. **15**, Fig. 1).

Patients.—10 ward huts (Pl. **63**, Fig. 3).

Accessories. (1)	Type plan. (2)		No required. (3)	Remarks. (4)
	Pl.	Fig.		
Patients				
Ablution places and baths	**64**	1	2	—
Administration block ...	**63**	1	1	—
Cookhouse	**14**	1	1	—
Disinfector block ...	**64**	2	1	—
Incinerator and bed-pan cleaning sheds	**61**	2	2	—
Latrines	**13**	2	—	4 seats.
Mortuary	**62**	2	1	—
Stores	**63**	2	1	—
Staff				
Ablution place and baths, other ranks	**13**	5	1	Less 2 ablution benches.
Bath and latrine block, female nursing staff	**13**	4	1	1 bath and 2 separate closets.
Cookhouse, other ranks ...	**14**	5	1	—
Dining room, other ranks	**12**	1	1	20 feet long.
Latrines, officers	—		1	1 seat.
Latrines, other ranks ...	**13**	2	1	3 seats.
Mess, officers	**10**	5	1	—
Mess, female nursing staff	**10**	5	1	1 extra bay in the mess room.

F. Remount depot (headquarters and 1 squadron)

(*see* Pl. 2)

Officers	9
W.Os. and serjeants	12
Rank and file	358
Riding horses	4
H.D. horses	26
Remounts	750

Standing camp

Partially hutted

ACCOMMODATION

All ranks.—Tents with tent bottoms.

Horses.—Picket lines or kraal system.

Accessories. (1)	Type plan. (2)	No required. (3)	Remarks. (4)
	Pl. Fig.		
Ablution places ...	13 1	—	—
Cooking shelter, officers	19	1	100 f.s.
Cooking shelter, other ranks	19	1	190 f.s.
*Disinfector shed ...	—	—	As required according to type.
*Drying room	13 3	½	—
*Dung pit or platform ...	—	1	For each stable.
*Exercising track with crush	68 2	1	As required.
*Incinerator shed ...	10 7	1	As required according to type.
*Kraal system	68 1	1	—
*Latrines, officers ...	—	1	1 seat.
*Latrines, other ranks ...	13 2	1	—
*Tramway for removal of dung	—	—	As required.

NOTE.—Other accessories in marquees or tents.

F. Remount depot (headquarters and 1 squadron) —*continued*

Hutted camp

ACCOMMODATION

Officers' living hut (based on Pl. **10**, Fig. 2).

Other ranks.—Living huts (Pl. **15**, Fig. 1).

Temporary personnel.—Tents with tent bottoms.

Horses.—Shelters (Pl. **65**, Fig. 4), in blocks of 126 stables.

Accessories marked * above are provided, and in addition—

Accessories. (1)	Type plan. (2) Pl.	Fig.	No. required. (3)	Remarks. (4)
Ablution places and baths, N.C.Os. and men	13	5	1	—
Cookhouse, other ranks ...	14	4	1	2 ranges and 2 boilers.
Dining room	12	2	1	Less 10 ft.
Dipping bath	69		1	If required.
Forage barn and granary	65	2	1	—
Forge and shoeing shed ...	65	3	1	For 6 forges and 9 posts.
General and clothing stores and quarter-master's office.	17	3	1	General and clothing stores each less 10 ft. in length. Rearrange racks, shelving and stoves as necessary.
Guard house, saddlers' shop, squadron office, and pharmacy	65	1	1	—
Officers' mess	10	5	1	—
Wash-up	10	9	1 single	—

G. Veterinary hospital for 1,000 sick animals

(*see* Pl. **3**)

Based on an establishment of—

Officers	6	6
W.Os. and serjeants	21	357
Rank and file	336	
Horses for transport, etc.	22	1,022
Horses, sick (including 250 isolation)	1,000	

G. Veterinary hospital for 1,000 sick animals—*continued*

Hutted camp

ACCOMMODATION

Officers.—1 living hut (Pl. **10**, Fig. 1).
Other ranks.—Living huts (Pl. **15**, Fig. 1).
Temporary personnel.—Tents with tent bottoms.
Horses.—Shelters, in blocks of 50 stalls (Pl. **65**, Fig. 4).

Accessories. (1)	Type plan. (2) Pl. Fig.	No. required. (3)	Remarks. (4)
Ablution places, other ranks	**13** 1	1	42 basins.
Barbers' shop	—	—	A portion of another hut.
Baths, other ranks ...	**13** 5	1	4 showers. Omit ablution places.
Boiler and dressing sheds	—	2	—
Clipping sheds	—	—	As required.
Cookhouse, other ranks ...	**14** 4	1	—
Dining room, other ranks	**12** 2	1	Less 20 ft.
Dipping bath	**69**	—	If required.
Disinfector shed	—	1	As required according to type.
Dressing and washing sheds for mange cases.	—	—	As required. Lean-to 14 ft. 9 in. wide.
Drying room	**13** 3	½	—
Dung pits or platforms ...	—	1	For each stable.
Exercising track with crush	**68** 2	1	As required.
Forage barn and granary	**65** 2	1	—
Forge and shoeing sheds	**65** 3	2	—
General and clothing stores and quartermaster's office.	**17** 3	1	Clothing store less 10 ft. in length. Re-arrange racks, etc., as necessary.
Guard house and offices	**16** 2	1	—
Incinerator shed	**10** 7	1	As required.
Isolation boxes	—	—	As required. 120 f.s. for each.
Latrines, officers	—	1	1 seat.
Latrines, other ranks ...	**15** 2	1	Number of seats, 5 per cent.
Medical inspection room and detention ward.	**60** 6	—	As required.
Officers' mess	**10** 5	1	Width, 16 ft.
Operation hut and slab ...	—	1	30 ft. by 28 ft.
Pharmacy and saddlers' and carpenters' shops...	—	1	—
Serjeants' mess	**11** 1	1	Mess room 20 ft. long.
Tramway for removal of dung	—	—	As required.
Wash-up	**10** 9	1 single	—

NOTE.—This scale may be followed, as far as applicable, for Convalescent Horse Depots. A proportion of the horses should be in kraals.

H. Prisoners of war camp for 500 prisoners

Standing camp

Partially hutted

ACCOMMODATION

Prisoners and escort.—Tents with tent bottoms.

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
	Pl. Fig.		
Ablution places ...	13 1	2	30 basins each.
Bath-house	—	—	20 ft. by 16 ft. 10 tubs separated by canvas screens; poles for seats; boiler house with tap inside, from which water is drawn for the baths.
Cooking shelter	19	1	250 f.s.
Disinfector shed	—	1	As required according to type.
Drying room	—	1	Width 16 ft.
Incinerator shed	—	1	As required according to type.
Latrines	13 2	1	—
Wash-house	—	1	30 ft. by 16 ft.

NOTE.—Other accessories in marquees and tents.

H. Prisoners of war camp for 500 prisoners—*continued*

Hutted camp

(*see* Pl. 8)

ACCOMMODATION

Officers.—1 hut, quarters and mess combined (based on Pl. 10, Fig. 4).

Prisoners.—21 living huts (Pl. 15, Fig. 1).

Escort.—1 living hut (*see* below).

All accessories shown above are provided, and, in addition—

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
Ablution places, escort ...	—	1	Lean-to.
Canteen and parcels room	—	1	400 f.s.
Cookhouse, escort ...	—	1	—
General and clothing stores and quarter-master's office	—	1	600 f.s.
Guard room	—	1	300 f.s. with detention enclosure 800 f.s.
Latrines, escort	—	1	—
Latrine, officers	—	1	1 seat.
*Medical inspection room and ward	—	1	—
Orderly room and office ...	—	1	450 f.s.
Serjeants' mess and dining room	—	1	Combined in 1 block with living hut, 2,250 f.s.
Tailors' and shoemakers' shops	—	1	200 f.s.
Workshops	—	1	200 f.s.

* Provision to be made as follows :—For 1 company, 6 beds.

Where 2 or more companies are adjacent, this ward to serve for all, but 10 beds should be provided for 2 companies and 12 beds for 3 companies. In cases where camps are isolated, 10 beds for a single company. Medical inspection room to be provided in this block.

I. Administrative and other units stationed in base areas

Standing camp

Partially hutted

ACCOMMODATION

All ranks.—Tents with tent bottoms.

Officers and serjeants' messes.—Marquees.

Office—Tent.

Horses—Picket lines.

Accessories. (1)	Type plan. (2)	No. required. (3)	Remarks. (4)
	Pl. Fig.		
*Ablution places ...	13 1	—	1 or more blocks according to size of unit.
Cooking shelters, officers	19	1	100 f.s.
Cooking shelters, serjeants	19	1	100 f.s., only provided if numbers of W.Os. and serjeants exceeds 20.
Cooking shelters, rank and file	19	—	Minimum 100 f.s. 1 or more blocks as convenient.
*Disinfector shed ...	—	1	As required according to type, and if cleansing station not provided.
*Drying-room	13 3	1	As required.
*Incinerator shed	10 7	1	As required according to type.
*Latrines, officers ...	13 2	1	
*Latrines, other ranks ...	13 2	—	1 or more blocks as convenient for size of unit.

I. Administrative and other units stationed in base areas—*continued*

Hutted camp

ACCOMMODATION

Officers.—Living huts and mess (Pls. **22** and **10**).

Warrant officers and serjeants.—Living huts and mess (Pls. **15** or **22**, **11**).

Rank and file.—Living huts (Pl. **15** or **22**).

Horses.—Shelters (Pl. **65**, 4).

Accessories marked * above are provided, and in addition—

Accessories. (1)	Type plan. (2) Pl.	Fig.	No. required. (3)	Remarks. (4)
Bath and latrine block, officers	**13**	4	1	—
Bathhouses	**46**	—	—	As authorized, and if no central cleansing stations or bath-houses are provided.
Cookhouse	**15**	3	1	—
Dining rooms	**12**	2	—	As required for size of unit.
General and clothing stores and quarter-master's office.	**17**	2	—	As required for size of unit.
Guardhouse and offices ...	**16**	1	—	As required for size of unit.
Medical inspection room and ward	**60**	6	—	As required for size of unit.
Officers' mess	**10**	—	—	As required for size of unit.
Serjeants' mess	**11**	2	—	As required for size of unit.
Regimental shops ...	**17**	—	—	As required for size of unit.
Wash-ups	**10** or **14**		—	As required for size of unit.

APPENDIX III

SCALE OF ELECTRIC LIGHT

1. The scale of electric light suggested is given in the table below.

2. The candle-power of electric lamps deteriorates with use and falls considerably if the voltage is appreciably below that for which the lamps are designed. It is, therefore, important that the lighting installed should be fully up to the scale.

3. The candle-power per watt of a gas-filled lamp is little better than that of a vacuum lamp below such sizes of the former as take about ½ ampere of current. In large huts the use of gas-filled lamps with suitable shades is economical, and the number of points to be installed can thus be less than with vacuum lamps.

4. The correct height for an electric lamp depends upon the purpose for which the light is required, the type of reflector used, and the spacing distance between the lamps. To obtain even distribution, the higher the lamps are placed the better. For general illumination, the minimum height of a vacuum lamp should be 10 ft., and that of a gas-filled lamp 12 ft. Gas-filled lamps should preferably be fitted with scientifically-designed reflectors.

Two rows of lamps are better than one row, so as to lessen shadows.

5. Provision should be made for illuminating the main roads and paths of hutment camps. The power required for this purpose should not usually exceed 4 per cent. of the power taken for the internal illumination of a camp.

6. Installations, store depots, etc., should be provided with internal and external lighting, as required.

7. The scales given are to be regarded as guides only, as many circumstances may arise which will necessitate their modification.

NOTE.—The energy consumption of vacuum lamps varies from 1·5 watts per m.s.c.p. to 1·25 watts per m.s.c.p. in the larger sizes of 100-volt lamps; and of gas-filled lamps from over 1 watt per m.s.c.p. in the smaller sizes to 0·7 watts per m.s.c.p. in the larger sizes.

Scale of lighting in terms of floor area

S.L.A.R. = Small lights as required. L.A.R. = Light as required.

Hut, room, etc. (1)	Sq. ft. per watt. (2)	Remarks. (3)
General		
Ablution places	8	1 light for each 10 f.r. of bench.
Ablution places and baths—		
Ablution places ...	8	
Baths	—	1 light to every 2 rooms.
Boiler houses	—	S.L.A.R. Wall socket, plug and hand lamps should be provided where necessary.
Dressing rooms... ...	8	
Showers	8	
Steam chambers ...	15	
Baths and latrines, officers	—	S.L.A.R.
Cookhouses	6	
Cooks' rooms	6	
Passages	—	S.L.A.R. Generally not exceeding 1 watt for each 15 f.s. and 400 f.s. for each lamp.
Sculleries	6	
Stores	6	
Cooking shelters	6	
Detention wards—		
Corridors	—	S.L.A.R. *See* passages.
Medical inspection room	4	
Other rooms	—	1 small light for each room, in lamp box.
Dining huts	5	1 light for each pair of sinks in wash-up.
Disinfector blocks ...	—	S.L.A.R.
Disinfector sheds ...	—	S.L.A.R.
Drying rooms	15	
Guard rooms	5	
Detention rooms ...	—	1 small light for each room, in lamp box.
Incinerator sheds ...	—	S.L.A.R.
Latrines	—	1 light over urinal.
Offices—		
Officers	5	1 light for each office table.
Clerks	4	With a minimum of 40 watts for every two clerks.
Drawing	1	
Shops—		
Barbers	4	L.A.R. Usually 1 light for each man working.
Carpenters	4	
Saddlers	4	
Shoemakers	4	

Scale of lighting in terms of floor area—continued

Hut, room, etc. (1)	Sq. ft. per watt. (2)	Remarks. (3)
General—contd.		
Shops—		
Tailors	4	
Workshops generally ...	—	L.A.R. to give an intensity of 8–5 ft. candles on the working plane. Additional local lighting by 40 or 60 watt lamps for individual machines requiring precision work.
Stables—		
Harness or saddle rooms	10	
Open	10	
Stalls	—	1 small light to 2 stalls, or in each loose box.
Stores—		
General and clothing ...	10	
Ration	10	
Verandahs	—	Generally not exceeding 1 watt per 15 sq. ft., and 400 sq. ft. per lamp. S.L.A.R. where used for sleeping or dining.
Wash-ups	—	1 light for each pair of sinks.
Messes		
Officers—		
Ante-room	3	
Kitchen	6	
Larder	6	
Lobby	10	
Mess room	3	
Store	6	
Waiters and cooks ...	6	
Serjeants—		
Cellar	15	
Kitchen	6	
Lobby	10	
Mess	3	
Store	10	
Quarters		
Corridors	—	S.L.A.R. Generally not exceeding 1 watt per 15 sq. ft. and 400 sq. ft. per lamp.
Cubicles in living huts ...	6	1 light for each 2 cubicles.
Living huts	6	
Nurses	3	
Officers	3	1 fixed and 1 standard light.
Servants' rooms	6	

Scale of lighting in terms of floor area—continued

Hut, room, etc. (1)	Sq. ft. per watt. (2)	Remarks. (3)
Hospitals		
Ablution places, patients—		
Officers	6	1 light for each 10 f.r. of bench.
Other ranks	8	Ditto.
Administration block—		
Consulting room ...	3	
Corridors	—	S.L.A.R. Generally not exceeding 1 watt per 15 sq. ft. and 400 sq. ft. per lamp.
Dispensary	4	
,, store ...	6	
Earth closets	—	S.L.A.R. 1 light over urinal.
Letter sorting room ...	4	
Matron's room	4	
Medical board room ...	4	
Nurses' night duty room	4	
Offices	4	
Orderly medical officer	3	
Telephone room ...	—	S.L.A.R. 1 light for each room.
Waiting room	6	
Baths, patients'—		
Officers'	—	S.L.A.R. 1 light for each room.
Other ranks	—	1 light every 2 rooms.
Baths and latrines, nurses	—	S.L.A.R.
Bed-pan cleaning shed	—	S.L.A.R.
General surgical dressing hut—		
Autoclave room ...	4	
Dressing room ...	8	
Waiting room ...	6	
Laboratory	3	
Latrines, patients'—		
Officers'	—	1 light for each row of latrines.
Other ranks	—	1 light over urinal.
Mortuary—		
Body chamber	—	S.L.A.R.
Post-mortem room ...	3	
Viewing room	4	
Operation hut—		
Dark room	—	S.L.A.R.
Nurses' room	4	
Operating theatre ...	1	Special light for operating table.
Robing room	4	
Splint room	4	
Sterilizing room ...	4	
Vestibule	10	
Washing room	4	
X-ray room	3	Special light as required.
Reception room ...	6	
Stores—		
Linen	10	
Pack	10	
Steward's	8	

Scale of lighting in terms of floor area—continued

Hut, room, etc. (1)	Sq. ft. per watt. (2)	Remarks. (3)
Hospitals—contd.		
Wards—		
Bed-pan store	10	
Corridor	—	S.L.A.R. Generally not exceeding 1 watt per 15 sq. ft. and 400 sq. ft. per lamp.
Earth closet, nurses ...	—	S.L.A.R.
Nurses' duty room ...	4	
Scullery	6	
Ward, ordinary... ...	4	Local lighting may be provided, one lamp to every 2 beds if required.
Ward, mental	4	
Ward, small	4	
Veterinary hospitals and remount depots		
Boiler and dressing sheds	—	S.L.A.R.
Clipping sheds	10	
Dressing and washing sheds for mange cases ...	10	
Forge and shoeing sheds...	6	
Operation huts	3	
Pharmacies	4	

APPENDIX IV

STANDARD WAR HUTTING

1. As stated in Part I, in order to facilitate the rapid production of accommodation required in an overseas theatre of war, standard types of war hutting have been designed.

They are of three general types :—

i. Living accommodation.
ii. Store sheds.
iii. Workshop sheds.

2. For (i) the standard type adopted in the Adams hut. illustrated on Pl. **22.**

3. For (ii) and (iii) standard buildings have been designed, The principal types are 28-ft. (clear) span as illustrated in Pl. **23**, Fig. 2, and 36-ft. (clear) span as illustrated in Fig. 1 on the same plate. These buildings may be built of steel and corrugated iron or of timber and corrugated iron. The steel buildings are made up of a few standard parts, the trusses consisting of angle sections with eyebar ends pin-jointed at the various junctions. These sections have been designed so that by variation in their arrangement the parts used in the assembly of the 28-ft. span can be made up into trusses of 18 ft. 6-in. (clear) span, and those used in the 36-ft. span can be made up to 23 ft. 10-in. (clear) span. Large sheds and workshops are made up of two or more of these standard buildings placed side by side, valley gutters being used at the junctions of their roofs.

The 28-ft. span standard huts can be adapted for use as large office blocks by dividing them up internally with partitions as required (Pl. **15**, Figs. 4 *et seq.*), and by providing the necessary floors, wall linings, ceilings, doors and windows.

Similarly the 24-ft. span standard huts can be adapted for use as dining rooms, smaller office blocks, etc.

4. The maximum width of store sheds in the field has been fixed at 108 ft. (nominal) made up of three 36-ft. (clear) spans, making a shed of a total width of 109 ft. 6 in. (including stanchions), and of 148 ft. including platform shelters on either side. Trusses are spaced at 15 ft. 3 in. centres, but, in order to save restriction in working space on the platforms

as much as possible, the stanchions supporting the outer eaves of the platform shelters are spaced at 30 ft. 6 in. centres, the intermediate trusses being carried on a 12 in. by 6 in. by 54 lb. R.S.J. The maximum width of workshop sheds has been fixed at 144 ft. (nominal) made up of four 36-ft. (clear) spans, making a shed of total width of 146 ft. including stanchions.

No platform shelters are provided for workshop sheds.

5. **Height of eaves.**—For store shedding, with the 36-ft. span hut a height of 14 ft. 6 in. to eaves has been fixed. The stanchions are 7 in. by 4 in. by 16 lb. R.S.J., and knee bracing is used to give the necessary rigidity to the whole structure.

In the case of workshops the eaves height is increased to 22 ft. 7 in. to permit of a two-ton traveller working inside the shed; and the stanchions are 12 in. by 6 in. by 54 lb. R.S.J. fitted with brackets to carry the traveller rail. No knee bracing is provided.

In the case of the 28-ft. span hut, the height to the eaves is fixed at 12 ft., regardless of the use to which the hut may be put.

6. **Lighting.**—Continuous roof lighting is provided on either side of the ridge in every bay of the workshops by means of standard light-fittings fixed in the corrugated sheets. Similar lighting may be provided for store sheds as required (Pl. **105**).

7. **Sheeting.**—The outer coverings are of corrugated sheeting, and to simplify supply the sheets required have been limited to 9-ft., 7 ft. 6-in. and 6-ft. lengths.

8. **Roller shutters.**—Standard roller pattern shutters are provided for workshop sheds as shown on plates. The type of roller shutter is illustrated on Pl. **145**.

9. Working drawings and quantities have been prepared for these standard sheds and are sealed.

10. The complete list of working drawings for which quantities have been prepared, and which are sealed is given in Table AA.

TABLE AA.—LIST OF WORKING DRAWINGS SEALED IN D. OF W. WAR CHEST

Item. (1)	Description. (2)	Nominal width. (3)		Dimensions height. (4)		Construction. (5)	Remarks. (6)
		ft.	in.	ft.	in.		
1	Living hut (Adams) ...	16	0	8	6	Steel and C.I.	Standard accommodation in theatre of war.
2	Standard living hut ...	18	6	8	6	Steel and C.I.	Standard accommodation in war training camps.
3	,, ,,	20	0	8	0	Timber and C.I.	
4	Standard hospital hut ...	18	6	8	6	Steel and C.I.	Standard hospital accommodation in theatre of war.
5	,, ,,	20	0	8	0	Timber and C.I.	
6	Standard building ...	24	0	12	6	Steel and C.I.	Standard building for hospital wards in tropics.
7	,, ,,	24	0	10	0	Timber and C.I.	
8	,, ,, ...	28	0	12	0	Steel and C.I.	Dining huts, standard building for office blocks, small store sheds or workshops.
9	,, ,, ...	28	0	12	6	Timber and C.I.	
10	,, ,, ...	36	0	14	6	Steel and C.I.	Standard stores buildings in the theatre of war.
11	,, ,, ...	36	0	14	6	Timber and C.I.	
12	Standard store shed (410 ft. by 148 ft.) ...	108	0	14	6	Steel and C.I.	With 19-ft. wide platform shelters on either side.
13	Standard workshop (404 ft. by 146 ft.) ...	144	0	22	7	Steel and C.I.	—
14	Miscellaneous camp structures— Cooking shelters Washing-up benches Ablution bench Latrines and urinals Shower baths Horse shelters Water supply and storage	—		—		—	—

APPENDIX V

CONSTANTS OF LABOUR

A. Labourers

ITEM.	*Excavating.*—			
1.	Vegetable earth, including filling into barrows	2¼	Y.C.	an hour.
2.	Sand, including filling into barrows ...	1⅔	,,	,,
3.	Clay ,, ,, ,, ,, ...	1	,,	,,
4.	Earth and coarse gravel, including filling into barrows	⅔	,,	,,
5.	Chalk, including filling into barrows ...	½	,,	,,
6.	Rock blasting, including filling into barrows	⅓	,,	,,
	(In items 1–6 for work in narrow trenches deduct ¼)		,,	,,
7.	Filling barrows, vegetable earth, loam, or sand, when not done with excavation ...	2¼	,,	,,
8.	Filling barrows, clay and stony earth ...	2	,,	,,
9.	,, ,, wet mud	1¾	,,	,,
10.	(Deduct 15 per cent. from above rates for filling tip carts)			
11.	Removing in barrows 25 yds., depositing and returning (add 3 yds. run for every foot rise)	3¼	,,	,,
12.	Ramming 6-in. layers	2½	,,	,,
13.	,, 12-in. ,, ...	4	,,	,,
14.	Levelling and trimming slopes to profile ...	10	Y.S.	,,
15.	Demolish brickwork (in lime mortar) ...	12	F.C.	,,
16.	,, ,, (in cement mortar) ...	8	,,	,,
17.	,, ,, (if cut with chisel) ...	4	,,	,,
18.	Clean and stack bricks (lime mortar) ...	140		,,
19.	Breaking bricks to 2¼-in. gauge	0·6	Y.C.	,,
20.	,, ,, 1¼-in. ,, ...	0·4	,,	,,
21.	,, stone to 2-in. ,, ...	0·2	,,	,,
22.	Concrete—Measuring, mixing, wheeling and levelling in layers, including turning over twice dry and twice wet	0·33	,,	,,
23.	Concrete, in narrow walls	0·20	,,	,,
24.	Fixing centering in roofs and walls, supports, easing and removing	1·5	Y.S.	,,
25.	Laying 5-in. P.C.C. and brought to fair surface	1·75	,,	,,
26.	Fixing steel for reinforcement in joists, stanchions, etc., excluding cutting and preparing	3	cwt.	,,
27.	Fixing rods, including fixing binding wires, but excluding cutting, bending, looping, etc., if only ⅜-in. in diameter	10	F.R.	,,
28.	Fixing expanded metal in concrete, including binding	2	Y.S.	,,
29.	Fixing expanded metal in ceilings, including binding	1·5	,,	,,

B. Bricklayers

ITEM.		Rough.	One fair face.	
30.	Brickwork in cement mortar.			
	4½-in.	70	40	Bricks an hour.
	9-in.	80	48	,, ,,
	13½	90	50	,, ,,
	18	100	60	,, ,,
	in line mortar add	6	4	,, ,,
	in mud mortar add	12	—	,, ,,
	(14 bricks go to one cubic foot).			,, ,,

31	Add for each external vertical corner or jamb set fair	8 F.R.	,,
32.	Rough arches	3 F.S.	,,
33.	Laying stone setts and grouting	10 ,,	,,
34.	Paving bricks on edge in cement	7·5 ,,	,,
35.	,, ,, curved in drains	6 ,,	,,
36.	Fixing concrete partition blocks	18 ,,	,,
37.	Setting brickwork in firegrate	2·5 F.C.	,,
38.	4-in. drain pipe-laying and jointing in cement	18 F.R.	,,
39.	6-in. ,, ,, ,, ,,	14 ,,	,,
40.	9-in. ,, ,, ,, ,,	9 ,,	,,
41.	12-in. ,, ,, ,, ,,	6·5 ,,	,,
42.	P.C. concrete in granite chippings laid, and floated on floors, 1½-in. to 2-in. thick ...	2 Y.S.	,,

C. Carpenters

43.	Planing rough timber	11 F.S.	,,
44.	,, ,, ,, including squaring ...	8 ,,	,,
45.	Repairing floor in patches under 5 f.s. ...	1	,,
46.	,, ,, ,, over 5 f.s. and under 50 f.s.	6 F.S.	,,
47.	Doors, 18 to 21 f.s. All thicknesses—		
	Ledged and braced	10 hours.	
	Framed and braced	12 ,,	
	Four panels	17 ,,	
	Hanging doors	1¾ ,,	
48.	Sash frames deal cased, wooden sill, etc., complete (whole opening measured) ...	1·5 F.S.	,,
49.	Sashes	2 F.S.	,,
50.	Fixing fir in roofs	3 F.C.	,,
51.	,, ,, in joists, wall plates, lintels, etc. ...	3 ,,	,,
52.	Hoisting and fixing roof trusses (28 ft. to 36 ft. spans). Gang of 13 men	2	,,
53.	Pine timber framed and fixed rough.		
	Fir under 16 sq. in. in section per cu. ft. ...	1·6 hours.	
	,, 36 ,, ,, ,, ...	1·4 ,,	
	,, 81 ,, ,, ,, ...	1·25 ,,	
	If wrot one side add 25 per cent.		
	,, two sides ,, 33 ,,		

54. Laying floors. 7-in. widths. Edges shot. R. & F. or P. & T.—

1-in.	42 F.S.	25 F.S.	an hour.
1¼-in.	38 ,,	23 ,,	,,
1½	34 ,,	20 ,,	,,

If in 4½-in. widths, deduct 33 per cent.

C. Carpenters—*continued*

ITEM.		
55.	Laying maple floors	24 F.S. an hour.
56.	,, roof boarding, 7-in. widths	
	¾-in.	40 ,, ,,
	1-in.	36 ,, ,,
	Add 5 F.S. for each extra in. width of boarding.	
57.	Preparing casing and shuttering, complete ...	40 ,, ,,
58.	Fixing skirting any section, including plugs	2 F.R. ,,

D. Smiths and gasfitters

59.	Fixing down pipes and gutters	12 ft. ,,
60.	,, rivets in C.I. sheeting	50 ,,
61.	,, W.I. pipes, per joint, ⅜ in. to 1 in. ...	8 ,,
62.	,, ,, ,, 1¼ in. to 2 in. ...	6 ,,
63.	Cutting and screwing W.I. pipes, ⅜ in. to 1 in.	3 ,,
64.	,, ,, ,, 1¼ in. to 2 in.	2 ,,
65.	Fixing 4½-in. O.G. gutter	18 F.R. ,,
66.	Laying and jointing C.I. mains, pipes from 3 in. to 5 in.	9 ,, ,,
67.	Laying and jointing C.I. mains, pipes from 6 in. to 9 in.	6 ,, ,,
68.	Laying and jointing C.I. mains, extra joints, 3 in. to 5 in.	each ¾ hour.
69.	Laying and jointing C.I. mains, extra joints, 6 in. to 9 in.	,, 1 ,,
70.	Laying and jointing Victaulic piping, 2 in. to 6 in.	200–150 F.R. an hour (2 men)
71.	Hoisting and fixing corrugated iron sheets ...	3 cwt. an hour.

E. Slaters

72.	Laying felt roofing	100 F.S. ,,
73.	Tarring ,, ,, ...	120 ,, ,,

F. Plasterers

74.	Lime and hair stuff mixing	3½ F.C. ,,
75.	Fine stuff and putty	2½ ,, ,,
76.	Rendering and pricking up	50 F.S. ,,
77.	,, set with fine stuff	30 ,, ,,
78.	Two coats and set	21 ,, ,,
79.	,, ,, float	23 ,, ,,
80.	Render and float in P.C. and sand 1-in. thick on floors	60 ,, ,,
81.	Render and float in P.C. and sand ¾-in. thick on walls	38 ,, ,,
82.	Render and rough cast	70 ,, ,,
83.	Fix fibro plaster or asbestos cement sheets on ceilings including stopping joints	30 ,, ,,
84.	Cutting edges of ditto	80 F.R. ,,
85.	Limewhiting, ordinary...	150 F.S. ,,
86.	,, large surface	225 ,, ,,
87.	Whiting and size, ...	130 ,, ,,
88.	,, ,, two coats	75 ,, ,,
89.	Colouring and distempering, ...	112 ,, ,,
90.	,, ,, ,, two coats ...	70 ,, ,,
91.	Fixing laths	80 ,, ,,

G. Plumbers

Item.		
92.	Bend 4-in. pipe, including fixing	3 hours.
93.	Soldered joint in $1\frac{1}{4}$-in. pipe	$\frac{1}{4}$ hour.
94.	Wiped taft joint	$\frac{1}{3}$,,
95.	Drawn lead trap	1 ,,
96.	Fixing $1\frac{1}{2}$-in. lead piping	3 F.R. an hour.
97.	Adjust, regulate, and re-washer ball valves and bib cocks	1 hour each.

H. Painters

98.	First coat on wood	56 F.S. an hour.
99.	Second coat on wood	64 ,, ,,
100.	Knotting and stopping	90 ,, ,,
101.	Painting railings on all sides seen (measured one side only)	90 ,, ,,
102.	Cutting in lines	47 F.R. ,,
103.	First coat on iron	52 F.S. ,,
104.	Second coat on iron, and following coats ...	60 ,, ,,
105.	Tarring roofs	120 ,, ,,
106.	First and other coats of paint on C.I. roofs...	100 ,, ,,
107.	Glass, new panes (ordinary sizes)	6 an hour.
108.	,, old panes hacked out	2 ,,
109.	Painting sashes both sides, including putty (measured one side only)	20 F.S. an hour.
110.	Lettering—H=height of letters in inches N=number of letters. Time required	$\frac{H \times N}{18}$ hours.
111.	Eaves gutters, including cleaning out and staunching joints	6 Y.R. an hour.

N.B.—The rates given above are for a man and his mate, or share of a mate as appropriate, and for a man of average skill.

Facing page 348.

APPENDIX VI

List of materials required for accessory Buildings in various Unit Camps.

Unit. Approx Strength	Item No.	Building	Size or Type	Amount or Number	Timber 6"×3"	Timber 4"×4"	Timber 3"×3"	Timber 3"×2"	Timber 3"×1½"	Timber 2"×2"	Timber 9"×1"	Timber 6"×1"	Timber 3"×1"	Timber 2"×1"	Nails 6" lbs	Nails 4" lbs	Nails 3" lbs	Nails 2" lbs	Nails [illegible]	Nails [illegible]	Nails G.C.H.	CGI Sheets 8' No	CGI Sheets 7' No	CGI Sheets 6' No	CGI Sheets Ridging	Doors & Windows [illegible]	Doors & Windows [illegible]	Hinges prs. Butt	Hinges prs. [illegible]	[illegible]	Water Supply Stores Piping 1½"	Piping 1"	Piping ¾"	Stopcocks 2"	Stopcocks 1½"	Taps ¾"	Tanks Galls 400	Tanks Galls 100	Tanks Galls 50	Iron etc. [illegible]	Iron etc. [illegible]	Iron etc. [illegible]	Item No.
1 BASE DEPOT. (1 Coy. Inf. B.D.) approx. strength 50 Officers 60 WOs & Sgts 925 R & F. Quantities for 1000.	a	Cooking Shelters Officers	10×40	1	-	-	67	158	-	-	-	-	35	8	-	3¼	-	½	-	-	114	-	11	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
		WOs & Sgts	10×40	1	-	-	67	155	-	-	-	-	35	8	-	3½	-	½	-	-	114	-	11	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		Men	10×40	4	-	-	268	630	-	-	-	-	140	38	-	14	-	2	-	-	456	-	44	88	-	-	-	-	-	-	-	-	40	-	-	10	-	-	-	-	-	-	
	b	Washing up benches	[illegible]	10	70	-	-	-	-	150	-	200	450	360	-	-	30	-	5	-	-	10	-	5	-	-	-	-	-	-	-	-	200	-	-	54	-	-	-	-	-	-	b
	c	Ablution Sheds	[illegible]	1600 f.s.	-	-	-	-	-	-	-	-	6000	-	-	-	-	24	-	-	2750	-	-	340	140	12	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c
		Benches	[illegible]	120 f.r.	100	-	-	460	-	-	920	-	480	-	-	-	24	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		Duckboards	[illegible]	280 f.r.	-	-	-	620	-	-	-	-	960	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	d	Latrines Officers	Pl. 14 fig. 20 & 23	120 f.s.	-	-	-	-	90	-	-	190	680	-	-	-	7	7	-	3	240	-	-	30	11	-	-	8	8	100	-	-	-	-	-	-	-	-	-	-	-	-	d
		NCOs and Men	do	720 f.s.	-	-	-	-	540	-	-	1080	4000	-	-	-	40	40	-	16	1426	-	-	172	64	-	-	50	50	600	-	-	-	-	-	-	-	-	-	-	-	-	
	e	Water Supply and Storage	Pl. 20 fig. 12		-	70	-	180	-	-	50	320	150	-	10	2	2	8	-	-	-	-	-	-	-	-	-	-	-	-	34	80	-	1	7	-	2	4	2	-	-	-	e
	f	Horse Troughs	Pl. 20 fig. [illegible]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	f
	g	Incinerators	Pl. 20 fig. 9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	6	g
				Totals.	170	70	400	2200	630	150	970	1780	2630	410	10	23	170	92	5	19	5100	10	66	686	215	12	30	58	58	700	34	80	240	1	7	64	2	4	2	60	-	6	
2 CAVALRY REGT. Establishment 27 Officers 37 WOs & Sgts 573 R & F. 570 Horses.	a			4	-	-	270	620	-	-	-	-	140	40	-	14	-	2	-	-	456	-	44	88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			7	50	-	-	-	-	100	-	130	320	260	-	-	22	-	4	-	-	7	-	4	-	-	-	-	-	-	-	-	28	-	-	7	-	-	-	-	-	-	b
	c	As		960 f.s.	60	-	-	650	-	-	560	-	4470	-	-	-	50	20	-	-	1660	-	-	200	84	8	18	-	-	-	-	-	120	-	-	32	-	-	-	-	-	-	c
	d			480 f.s.	-	-	-	-	420	-	-	840	3000	-	-	-	38	32	-	12	1104	-	-	135	50	-	-	36	36	440	-	-	-	-	-	-	-	-	-	-	-	-	d
	e	Above.			-	70	-	140	-	-	40	280	100	-	8	2	6	8	-	-	-	-	-	-	-	-	-	-	-	-	28	60	-	1	5	-	2	3	1	-	-	-	e
	f			96 f.r.	-	-	-	1060	-	-	-	-	-	-	-	32	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	10	102	-	-	-	-	-	-	-	280	-	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	6	g
				Totals.	110	70	270	2470	420	100	600	1250	8030	300	8	48	110	62	4	12	3220	7	44	454	134	8	18	36	36	440	28	70	250	1	5	39	2	3	1	60	280	6	
3 FIELD BDE. R.A. 28 Officers 38 WOs & Sgts. 843 R & F. 824 Horses.	a			5	-	-	340	780	-	-	-	-	180	40	-	18	-	3	-	-	570	-	55	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			9	60	-	-	-	-	130	-	180	410	330	-	-	27	-	5	-	-	9	-	5	-	-	-	-	-	-	-	-	36	-	-	9	-	-	-	-	-	-	b
	c	As		1440 f.s.	90	-	-	970	-	-	830	-	8700	-	-	-	75	30	-	-	2500	-	-	300	126	12	27	-	-	-	-	-	168	-	-	48	-	-	-	-	-	-	c
	d			720 f.s.	-	-	-	-	540	-	-	1080	4000	-	-	-	40	40	-	16	1420	-	-	172	64	-	-	50	50	600	-	-	-	-	-	-	-	-	-	-	-	-	d
	e	Above.			-	70	-	160	-	-	50	300	150	-	10	2	8	8	-	-	-	-	-	-	-	-	-	-	-	-	34	80	-	1	5	-	2	4	1	-	-	-	e
	f			138 f.r.	-	-	-	1520	-	-	-	-	-	-	-	46	-	-	-	-	-	-	-	30	-	-	-	-	-	-	-	15	140	-	-	-	-	-	-	-	370	-	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	6	g
				Totals.	150	70	340	3450	540	130	880	1560	13440	370	10	66	150	81	5	16	4490	9	55	624	190	12	27	50	50	600	34	95	344	1	5	57	2	4	1	60	370	6	
4 FIELD COY. R.E. 6 Officers. 7 WOs & Sgts. 253 R & F. 69 Horses.	a			2	-	-	140	310	-	-	-	-	70	20	-	7	-	1	-	-	228	-	22	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			3	20	-	-	-	-	40	-	60	140	110	-	-	9	-	2	-	-	3	-	2	-	-	-	-	-	-	-	-	12	-	-	3	-	-	-	-	-	-	b
	c	As.		480 f.s.	30	-	-	330	-	-	280	-	2240	-	-	-	25	10	-	-	830	-	-	100	42	4	9	-	-	-	-	-	56	-	-	16	-	-	-	-	-	-	c
	d			216 f.s.	-	-	-	-	160	-	-	320	1220	-	-	-	13	13	-	5	430	-	-	54	20	-	-	14	14	180	-	-	-	-	-	-	-	-	-	-	-	-	d
	e	Above			-	50	-	90	-	-	30	90	40	-	4	2	3	4	-	-	-	-	-	-	-	-	-	-	-	-	20	38	-	1	2	-	1	1	1	-	-	-	e
	f			12 f.r.	-	-	-	140	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	2	12	-	-	-	-	-	-	-	32	-	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	6	g
				Totals	50	50	140	870	160	40	310	470	3710	130	4	13	50	28	2	5	1488	3	22	210	62	4	9	14	14	180	20	40	80	1	2	19	1	1	1	60	32	6	
5 DIVL. SIGNAL COY. 21 Officers. 27 WOs & Sgts 435 R & F. 183 Horses.	a			4	-	-	270	620	-	-	-	-	140	30	-	14	-	2	-	-	456	-	44	88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			6	40	-	-	-	-	90	-	120	270	220	-	-	18	-	3	-	-	6	-	3	-	-	-	-	-	-	-	-	24	-	-	6	-	-	-	-	-	-	b
	c	As		720 f.s.	45	-	-	480	-	-	420	-	3350	-	-	-	38	15	-	-	1250	-	-	150	63	6	13	-	-	-	-	-	84	-	-	24	-	-	-	-	-	-	c
	d			396 f.s.	-	-	-	-	300	-	-	600	2200	-	-	-	22	22	-	9	780	-	-	95	35	-	-	26	26	330	-	-	-	-	-	-	-	-	-	-	-	-	d
	e	Above			-	50	-	120	-	-	40	180	100	-	7	2	6	5	-	-	-	-	-	-	-	-	-	-	-	-	28	60	-	1	4	-	1	3	1	-	-	-	e
	f			30 f.r.	-	-	-	330	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	3	30	-	-	-	-	-	-	-	80	-	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	6	g
				Totals.	85	50	270	1550	300	90	460	900	6060	250	7	26	84	44	3	9	2486	6	44	349	98	6	13	26	26	330	28	63	138	1	4	30	1	3	1	60	80	6	
[illegible]	a			[illegible]	-	-	[illegible]	[illegible]	-	-	-	-	210	50	-	21	-	3	-	-	684	-	66	132	-	-	-	-	-	-	-	-	[illegible]	-	-	[illegible]	-	-	-	-	-	-	a
[illegible] 118 Horses	e	Above			-	70	-	180	-	-	50	320	100	-	10	2	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	-	-	-	e
	f			24 f.r.	-	-	-	260	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	3	24	-	-	-	-	-	-	-	[illegible]	-	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	6	g
				Totals	150	70	400	2200	500	150	780	1020	10010	410	10	31	145	75	5	15	4224	10	66	576	172	12	23	45	45	560	34	83	214	1	7	52	2	4	2	60	64	6	
7 FIELD AMBULANCE 11 Officers 21 WOs & Sgts 199 R & F. 53 Horses	a			2	-	-	140	310	-	-	-	-	70	20	-	7	-	1	-	-	228	-	22	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			3	20	-	-	-	-	40	-	60	140	110	-	-	9	-	2	-	-	3	-	2	-	-	-	-	-	-	-	-	12	-	-	3	-	-	-	-	-	-	b
	c	As		360 f.s.	24	-	-	240	-	-	210	-	1680	-	-	-	19	8	-	-	625	-	-	75	32	3	7	-	-	-	-	-	42	-	-	12	-	-	-	-	-	-	c
	d			216 f.s.	-	-	-	-	160	-	-	320	1220	-	-	-	13	13	-	5	430	-	-	54	20	-	-	14	14	180	-	-	-	-	-	-	-	-	-	-	-	-	d
	e	Above			-	50	-	90	-	-	30	90	40	-	4	2	3	4	-	-	-	-	-	-	-	-	-	-	-	-	20	38	-	1	2	-	1	1	1	-	-	-	e
	f			12 f.r.	-	-	-	140	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	2	12	-	-	-	-	-	-	-	32	-	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	6	g
				Totals	44	50	140	780	160	40	240	470	3160	130	4	13	44	26	2	5	1283	3	22	185	52	3	7	14	14	180	20	40	66	1	2	15	1	1	1	60	32	6	
8 TANK BN 41 Officers 45 WOs & Sgts 472 R & F	a			4	-	-	270	620	-	-	-	-	140	30	-	14	-	2	-	-	456	-	44	88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			6	40	-	-	-	-	90	-	120	270	220	-	-	18	-	3	-	-	6	-	3	-	-	-	-	-	-	-	-	24	-	-	6	-	-	-	-	-	-	b
	c	As		720 f.s.	45	-	-	480	-	-	420	-	3350	-	-	-	38	15	-	-	1250	-	-	150	63	6	13	-	-	-	-	-	84	-	-	24	-	-	-	-	-	-	c
	d			480 f.s.	-	-	-	-	420	-	-	840	3000	-	-	-	32	32	-	12	1104	-	-	135	50	-	-	36	36	440	-	-	-	-	-	-	-	-	-	-	-	-	d
	e	Above			-	50	-	120	-	-	40	180	100	-	7	2	6	5	-	-	-	-	-	-	-	-	-	-	-	-	28	60	-	1	4	-	1	3	1	-	-	-	e
	f				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	6	g
				Totals	85	50	270	1220	420	90	460	1140	6860	250	7	16	94	54	3	12	2810	6	44	383	113	6	13	36	36	440	28	60	108	1	4	30	1	3	1	60	-	6	
9 C.C. STATION 12 Officers 10 WOs & Sgts 76 R & F.	a			2	-	-	140	310	-	-	-	-	70	20	-	7	-	1	-	-	228	-	22	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			2	14	-	-	-	-	30	-	40	90	70	-	-	6	-	1	-	-	2	-	1	-	-	-	-	-	-	-	-	8	-	-	2	-	-	-	-	-	-	b
	c	As		168 f.s.	10	-	-	120	-	-	100	-	750	-	-	-	8	4	-	-	280	-	-	35	14	1	2	-	-	-	-	-	20	-	-	6	-	-	-	-	-	-	c
	d			96 f.s.	-	-	-	-	90	-	-	180	600	-	-	-	6	6	-	2	220	-	-	27	10	-	-	7	7	90	-	-	-	-	-	-	-	-	-	-	-	-	d
	e	Above			-	-	-	60	-	-	20	60	70	-	3	-	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	3	-	-	1	2	-	-	-	e
	f				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	6	g
				Totals	24	-	140	490	90	30	120	280	1580	90	3	7	25	12	1	2	728	2	22	114	24	1	2	7	7	90	-	20	28	-	3	8	-	1	2	60	-	6	
10 CORPS H.Q. 32 Officers 22 WOs & Sgts 135 R & F 8 Horses	a			2	-	-	140	310	-	-	-	-	70	20	-	7	-	1	-	-	228	-	22	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			3	20	-	-	-	-	40	-	60	140	110	-	-	9	-	2	-	-	3	-	2	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	b
	c	As		240 f.s.	15	-	-	170	-	-	120	-	1120	-	-	-	13	5	-	-	420	-	-	50	21	2	5	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	c
	d			216 f.s.	-	-	-	-	160	-	-	320	1220	-	-	-	13	13	-	5	430	-	-	54	20	-	-	14	14	180	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	d
	e	Above			-	-	-	60	-	-	20	70	80	-	3	-	5	1	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	e
	f			6 f.r.	-	-	-	70	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	g
				Totals	35	-	140	610	160	40	140	450	2560	130	3	9	40	20	2	5	1078	3	22	[illegible]	41	2	5	14	14	180	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60	16	[illegible]	
11 DIVL. H.Q. 18 Officers 12 WOs & Sgts 80 R & F 16 Horses	a			2	-	-	140	310	-	-	-	-	70	20	-	7	-	1	-	-	228	-	22	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			2	14	-	-	-	-	30	-	40	90	70	-	-	6	-	1	-	-	2	-	1	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	b
	c	As		168 f.s.	10	-	-	120	-	-	100	-	780	-	-	-	8	4	-	-	280	-	-	35	14	1	2	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	c
	d			120 f.s.	-	-	-	-	110	-	-	[illegible]	750	-	-	-	8	8	-	3	280	-	-	34	12	-	-	9	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	d
	e	Above			-	-	-	60	-	-	20	60	70	-	3	-	5	1	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	e
	f			6 f.r.	-	-	-	70	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	g
				Totals	24	-	140	560	110	30	120	[illegible]	1130	90	3	9	23	14	1	3	788	2	22	[illegible]	[illegible]	1	2	9	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
12 BRIGADE H.Q. 10 Officers 4 Sgts 45 R & F 11 Horses	a			1	-	-	70	160	-	-	-	-	40	10	-	4	-	1	-	-	114	-	11	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a
	b			2	14	-	-	-	-	30	-	40	90	70	-	-	6	-	1	-	-	2	-	[illegible]	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	b
	c	As		96 f.s.	6	-	-	60	-	-	60	-	400	-	-	-	5	5	-	-	160	-	-	18	8	1	1	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	c
	d			72 f.s.	-	-	-	-	60	-	-	110	400	-	-	-	4	4	-	2	140	-	-	18	7	-	-	5	5	60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	d
	e	Above			-	-	-	40	-	-	20	40	50	-	2	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	e
	f			6 f.r.	-	-	-	70	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	f
	g			1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	g
					20	-	70	330	60	30	80	190	980	80	2	6	18	8	1	2	404	2	11	68	15	1	1	5	5	60	-	15	26	-	2	6	-	1	1	60	16	6	

NOTES. i. Figures for Timber allow for 10% cutting to waste.

ii. Quantities are calculated on the designs given in Column 4. If other designs are adopted, they must be adjusted accordingly.

iii. Item e. Water Supply, allows for a minimum of piping for connecting all tanks to a main. A normal allowance for nipples, back nuts, bends and other fittings must be made for this, & Item f Horse troughs.

iv. Where windows and doors are specified, supply is assumed to include the requisite framing.

APPENDIX VII

LIST OF ELECTRICAL STORES REQUIRED FOR THE LIGHTING OF VARIOUS BUILDINGS, ETC.

A. Hutted camp for 1,000 officers and other ranks (Pl. 1)

1. *With cleat wiring*

Lampholders, B.C., S.C., and C.G.	450
Cord, Electric, U. class, 0·0010, twin	700 yds.
,, ,, U.N. class, 0·0010, twin	200 yds.
Counterweights, small, complete	30
Shades, conical, iron, enamelled, 10-in. shallow ...	420
,, ,, glass, opal, white, 10-in., shallow	120
Switches, tumbler, 5-amp., S.P., 1-way...	324
Bulkhead, fitting, complete	2

*Standards, table, complete, without plug or shade ...	50
*Shades, opal, glass, green, deep...	50
*Wall sockets and plug, with switch combined, surface, 2-pin, 5-amp.	60

Tubing, ¾-in.	1,500 F.R.
Saddles, ¾-in., single	1,000
Bends, normal, inspection, ¾-in.	24
Couplers, screwed, ¾-in.	84
Tees, inspection, ¾-in.	24
Brackets, iron, flat, ¾-in., tubing, 18-in., projection exterior, complete	12
Boxes, circular, large, through	12
Bushes, insulating, exterior, ¾-in.	200
Reducers, screwed, 1-in. to ¾-in....	24
Screws, I.C. brass, cheese-headed, No. O.B.A. ...	1 gross
Boxes, switch, watertight, terminal, D.P. switch and fuse, 5-amp. I.C.	12
Bends, solid, normal, ¾-in.	60
Screws, R.H., 1¼ in. or 1-in., No. 8, brass or iron ...	12 gross

Cable, electric, J. class, single, taped and braided, JO. 002	10,000 yds.
Cable, electric, J. class, single, taped and braided, JO. 0045	400 yds.
Cleats, porcelain, double, grooves, ¼-in.	6,000
,, ,, treble grooves, ¼-in.	2,000
Screws, R.H. 1½-in., No. 60, brass or iron	70 gross
Boxes, junction, 4-plate, K. and M.	240
Roses, ceiling, cleat pattern	480
Blocks, wood, K. and M.	240
Blocks, wood, round, 3-in. teak	300

* Officers' quarters.

A. Hutted camp for 1,000 officers and other ranks —*continued*

1. *With cleat wiring*—continued

Blocks, wood, 6-in. by 3-in. teak	96
,, ,, 6-in. by 3-in. teak	96
Screws, F.H., ¾-in., No. 6, brass or iron	12 gross
,, ,, 2-in., No. 10 or 12, brass or iron ...	10 gross
Main, switch and fuses, I.C.W.T., 5-amp. D.P. ...	50
,, ,, ,, ,, 30-amp. D.P. ...	4
Boards, distribution, fuse, D.P., commercial wood—	
5-amp., 2-way	2
5-amp., 3-way	3
5 amp., 4-way	3
Lamps, electric, incandescent, B.C. internally frosted—	
Volts, 15 watts (vacuum)	50
,, 25 ,, do.	200
,, 40 ,, (gas-filled)	300
,, 60 ,, do.	50

2. *With T.R.S. wiring*

Lampholders, B.C., S.C. and C.G.	450
Cord, electric, U. class, 0·0010, twin	700 yds.
,, ,, U.N. class, 0·0010, twin	200 yds.
Counterweights, small, complete	30
Shades, conical, iron, enamelled, 10-in., shallow ...	420
,, ,, glass, opal, white, 10-in., shallow ...	120
Switches, tumbler, 5-amp., S.P., 1-way...	324
Bulkhead, fitting, complete	2

*Standards, table, complete, without plug or shade ...	50
*Shades, opal, glass, green, deep	50
*Wall sockets and plug, with switch combined, surface, 2-pin, 5-amp.	60

Tubing, ¾-in.	200 F.R.
Saddles, ¾-in., single	100
Bends, normal, inspection, ¾-in.	12
Couplers, screwed, ¾-in.	36
Tees, inspection, ¾-in.	12
Brackets, iron, flat, ¾-in. tubing, 18-in. projection, exterior complete.	12
Boxes, circular, large, through	12
Bushes, insulating, exterior, ¾-in.	24
Reducers, screwed, 1-in. to ¾-in.	24
Screws, I.C. brass, cheese-headed, No. O.B.A. ...	1 gross
Boxes, switch, watertight, terminal, D.P. switch and fuse, 5-amp., I.C.	12
Cable, electric, N. 0·002 T.R.S., single	10,000 yds.
,, ,, N. 0·0045 T.R.S. single	400 yds.
Clips, fibre (2 single wires)	12,000
,, ,, (3 single wires)	1,500
,, ,, (4 single wires)	300

* Officers' quarters.

A. Hutted camp for 1,000 officers and other ranks —*continued*

2. *With T.R.S. wiring*—continued

Screws, R.H., 1½-in., No. 6, brass or iron	105 gross
Blocks, wood, K. and M.	700
Boxes, junction, 3-plate, K. and M.	240
Roses, Ceiling, K. and M. type, 3-plate...	480
Blocks, wood, round, 3-in., teak	300
„ „ 6-in. by 3-in., teak	96
Screws, F.H., ¾-in., No. 6, brass or iron	18 gross
„ „ 2-in., No. 10 or 12, brass or iron ...	10 gross
Main, switch and fuses, I.C.W.T., 5-amp., D.P. ...	50
„ „ „ „ 30-amp., D.P. ...	4
Boards, distribution, fuse, D.P. commercial wood—	
5-amp., 2-way	2
5-amp., 3-way	3
5 amp., 4-way	3
Lamps, electric, incandescent, B.C. internally frosted—	
Volts, 15 watts (vacuum)	50
„ 25 „ do.	200
„ 40 „ (gas-filled)	300
„ 60 „ do.	50

B. E.L. Stores required for 10,000 sq. ft. of Standard Workshops or Stores

Item No.	Article and Specification.	Unit.	Quantity.		Item No.	Remarks.
			Workshops.	Stores.		
1	Boards, distributing, 5/10A D.P. fuze, 6-way, iron	No.	2	—	1	
2	,, ,, ,, ,, 4-way, ,, ...	No.	2	2	2	
3	Bolts and nuts, iron, hexagon head, $\frac{3}{8}$-in. × $1\frac{1}{2}$-in. (Whit)... ...	Gross	1	1	3	
4	Boxes, switch, iron, rect., $\frac{3}{4}$-in. terminal, with 2 bakelite 5-amp. semi-recessed switches	No.	4	—	4	
5	Boxes switch, iron, rect., $\frac{3}{4}$-in. terminal, with 3 bakelite, 5-amp. semi-recessed switches	No.	—	2	5	
6	Bushes, insulating, external, 1-in. conduit	Doz.	2	1	6	
7	,, ,, ,, $\frac{3}{4}$-in. ,, ...	Doz.	3	3	7	
8	Cable Elec., J. ·002 low, single	Yds.	1,600	1,400	8	
9	,, J. ·003 ,, ,, ...	Yds.	300	—	9	
10	,, J. ·0145 ,, ,, ...	Yds.	—	500	10	
11	,, J. ·03 ,, ,, ...	Yds.	100	—	11	
12	,, J. ·06 ,, ,, ...	Yds.	150	—	12	
13	Cable racks, 2-way, small, with insulators	No.	12	12	13	
14	,, 4-way, ,, ,, ...	No.	15	15	14	
15	Cleats, porcelain, 2-groove, $1\frac{1}{2}$-in.	Gross	10	10	15	
16	,, ,, 3-groove, ,, ...	Gross	3	3	16	
17	Connectors, K.M. 3-plate, with block	No.	6	6	17	
18	Connector box, iron, D.P. Tee, 50-amp.	No.	1	—	18	
19	Cord, elec. flexible, U. 001, twin	Yds.	200	200	19	
20	,, ,, U.N. ·001 twin	Yds.	200	100	20	
21	Chain, $\frac{3}{4}$-in. link, iron, light	Ft.	380	—	21	
22	Handlamps, portable, interior	No.	12	6	22	

23	Iron strip, 1-in. × $\frac{1}{16}$-in.	lb.	30	30	23
24	Lamps, electric, ? volts, 200 W. E.S., G.F., clear	No.	38	—	24
25	,, ,, ? volts, 40-W., B.C., G.F., I.F.	No.	14	48	25
26	Lampholders, B.C., Sh. C., C.G.	No.	—	42	26
27	Locknuts, 1-in. conduit	Doz.	3	1	27
28	,, $\frac{3}{4}$-in. ,, ...	Doz.	—	2	28
29(*a*)	Pendants, dispersive type, 200-watt, with susp. hook and E.S. holder	No.	36	—	29 (*a*)
29(*b*)	Pendants, concentrating type, 200-watt, with susp. hook and E.S. holder	No.	36	—	29 (*b*)
30	Roses, ceiling, cleat wiring type	Doz.	$3\frac{1}{2}$	$3\frac{1}{2}$	30
31	Saddles, single, $\frac{3}{4}$-in., enamel	Gross	$\frac{1}{3}$	$\frac{1}{2}$	31
32	Screws, wood, I.R. head, $1\frac{1}{2}$-in. × G10	Gross	12	12	32
33	,, ,, I.F. ,, 1-in. × G8	Gross	2	2	33
34	,, ,, I.F. ,, $\frac{3}{4}$-in. × G6	Gross	2	2	34
35	Screws, iron, R. head, $1\frac{1}{2}$-in. × $\frac{1}{4}$-in. Whit.	Gross	1	1	35
36	Shades, enamel iron, 10-in. shallow	Doz.	—	$3\frac{1}{2}$	36
37	Switch and fuze, I.C. weatherproof, D.P., 30-amp.	No.	2	—	37
38	,, ,, ,, ,, ,, 10-amp.	No.	—	2	38
39	Wall socket plug and switch combined, 3-pin, 5-amp., iron, term. scr. $\frac{3}{4}$-in.	No.	24	14	39
40	Tubing, steel welded, 1-in., galvanized	F.R.	150	30	40
41	,, ,, $\frac{3}{4}$-in. ,, ...	F.R.	400	250	41
42	Washers, iron, $\frac{3}{8}$-in.	lb.	2	2	42
43	Wood batten, deal, 2-in. × 1-in. in 15 ft. lengths, approx. ...	F.R.	1,400	1,400	43

(Item 29(*a*) for shops *with* crane. Item 29(*b*) for shops *without* crane.)

APPENDIX XI

INSTRUCTIONS REGARDING PRECAUTIONS TO BE TAKEN WHEN PAINT SPRAYING APPARATUS IS BEING USED

1. Lead basis paint will not be used for paint spraying.

2. Normally only "lead free" paint will be used, and will be demanded through the normal channels. In the event of local purchase of paints becoming necessary, such paints must be analysed and must not yield lead compounds, when calculated as lead monoxide, exceeding 5 per cent. of the dry weight of the portion taken for analysis.

3. If "cellulose" is used, precautions are to be taken against fire, as the material is highly inflammable. Very elaborate precautions regarding forced ventilation, heavy insulation of electrical wiring, sparkless switches, spark-proof motors for fans, etc., have to be taken.

- i. A ventilating fan will be installed, sufficient to renew the air in the room 30 times a day.
- ii. Incandescent electric light is the only official light allowed. The electric bulbs will be in thick glass containers. The switches and fuzes should be outside the building.
- iii. No open fires of any description or any smoking will be allowed.
- iv. Cellulose solutions and inflammable liquids must not be stored in the room where painting operations are carried out, but kept in a fire-proof building as air-tight as possible. The actual work room should not have more than 5 gals. of these inflammable liquids in at any one time.
- v. "Foam" type fire extinguishers on a scale of 2 gals. for every 250 superficial yards are required.
- vi. Where an electrical or I.C. engine type of spraying apparatus is employed, only the air line will be taken into the spraying compartment, except where, in the case of electric motors, they are of the totally enclosed type.
- vii. All wiring in the spraying compartment will be enclosed in screened conduit.

4. In either case (paras. 2 and 3 above) the operator will be protected by using a respirator.

APPENDIX VIII.

List of Materials required for a Hutted Camp for 1000 men.

(Referred to in Sec. 14)

Officers' Accomodation	Plate Ref	Size	No Req.d	LIST OF MATERIALS: Timber 8"x1"							C I Sheets 9'			Ridging 6'	Inner Lining Squares	Windows	Doors Outer		Heating Stoves	Stove Piping Ft Run	Galv Screws Washers	Concrete Cement tons			Nails (in lbs) 6"				Electric Lights
				8"x1"	6"x1"	4"x3"	4"x2"	3"x3"	3"x2"	Boards Squares	9'	7'6"	6'				Outer	Inner				Cement tons	Sand Y.C.	Agg.te Y.T.	6"	5"	4"	2½"	
Mess.		90'x20'	1	250	/	420	3000	1900	840	22	96	/	158	15	47	17	2	9	3	44	2,500	/	/	/	15	20	56	84	9
Quarters.		84'x28'	1	320	160	50	3,700	1240	2,130	27.5	100	150	37	/	147	20	4	8	3	32	3,100	/	/	/	20	26	72	110	19
Bath & Latrines		16'6"x8'3"	1	/	80	40	80	130	120	/	22	/	15	3	/	1	1	4	/	/	400	·33	1	2	12	2	5	6	2
W.O's & Sjts. Acc.n																													
Mess.		90'x20'	1	250	/	440	3,600	1900	840	22	110	/	158	15	47	17	2	6	1	15	2,500	·2	·6	1·1	15	20	56	84	7
W.O's Hut.		60'x16'	1	200	/	50	1680	900	1,060	11	66	/	106	11	38	9	1	6	6	200	1,650	/	/	/	10	12	34	50	8
Men's Accomod.n																													
Sleeping Huts.		60'x16'	40	2,600	/	1840	51280	24,400	23,200	528	3,600	/	3600	440	880	480	80	40	40	220	60,000	/	/	/	320	400	1200	1800	120
Cookhouse.		90'x28'	1	360	1190	90	1150	830	1800	/	130	176	64	/	55	16	3	8	/	/	2,900	62	185	37	23	28	84	180	13
Dining Room		100'x28'	2	580	2980	120	7200	2,060	3720	65·4	224	352	110	/	44	40	4	/	4	80	8,800	/	/	/	48	60	144	216	8
Latrines.		21'x18'	4	/	/	370	490	670	1,840	3·0	/	220	230	8	/	/	/	/	/	/	640	3·2	9·5	19	14	18	48	72	/
Ablution Sheds		36'x12'	4	/	/	184	1180	640	1,260	/	/	300	/	7	/	7	3	1	/	/	600	1·0	3	6	3	4	12	18	/
Drying Room		20'x20'	1	/	/	35	310	180	265	/	/	35	35	4	/	3	1	/	2	30	630	·75	2·3	4·6	3	4	12	18	2
Regimental Acc.n																													
Gd. Rm. & Rgtl. Offices		70'x20'	1	210	/	325	3,170	960	970	20	80	24	112	13	43	7	3	2	3	45	2,200	/	/	/	12	15	44	65	8
Coy. Offices & Stores		80'x16'	2	440	/	96	4,330	1,620	1700	30	170	/	280	28	02	28	12	8	4	60	4,000	/	/	/	20	28	80	12	24
Regimental Stores		70'x20'	1	210	/	325	3170	830	880	20	80	/	123	13	41	11	3	/	2	30	2,200	/	/	/	12	15	44	65	7
Regimental Shops.		30'x20'	1	120	/	190	820	400	400	7	44	/	48	7	11	3	3	/	/	/	1750	/	/	/	5	6	9	28	3
Totals.			62	10,540	5,410	4,555	91,460	38,650	40,925	808·5	4,722	1,317	7,076	564	1415	639	122	92	68	1,256	93,870	11·68	34·9	69·7	532	658	1900	2,658	230

APPENDIX IX

LIST OF MATERIALS REQUIRED FOR CONSTRUCTION OF VARIOUS BASE DEPOTS.

Description	Size	Number	Standard Steel & C.I. Store Sheds 36' Span Bays	Store Sheds 36' Span Ends	Store Sheds 28' Span Bays	Store Sheds 28' Span Ends	Workshops 36' Span Bays	Workshops 36' Span Ends	Roller Shutters	Timber Ft. Run 8"x1"	6"x1"	4"x3"	4"x2"	3"x3"	3"x2"	G.C.I. Sheets 9'0"	7'6"	6'0"	Ridging 6'0"	Galv. Screws and Washers	Boarding (Squares)	Inner Lining (Squares)	Windows	Doors	Concrete Cement Tons	Sand Yds. C.	Agg'te Yds. C.	Nails (Lbs) 6"	5"	4"	2½"
R.A.S.C. Main Supply Depot.																															
1. Storage Sheds.	395'x108'	8	624	48	—	—	—	—	96	—	—	—	—	—	—	—	—	—	—	—	—	—	208	—	1,088	2630	5260	—	—	—	—
2. Main Office.	28'x90'	1	—	—	7	2	—	—	—	360	—	100	2770	820	1700	—	—	—	—	—	27	83	20	8	—	—	—	16	18	40	60
3. Latrines.	21'x18'	4	—	—	—	—	—	—	—	—	—	370	490	670	1840	—	220	230	8	640	36	—	—	—	32	95	19	14	18	48	72
4. Ablution Sheds.	36'x12'	4	—	—	—	—	—	—	—	—	—	184	1180	640	1260	—	360	—	28	600	—	—	28	4	1	3	6	12	16	48	72
5. Guard Room.	36'x20'	1	—	—	—	—	—	—	—	120	—	170	1590	480	490	40	12	56	7	1100	8	22	8	2	—	—	—	6	8	22	33
6. Fire Engine Shed.	36'x20'	1	—	—	—	—	—	—	—	—	—	170	870	440	490	40	12	56	7	1100	—	—	—	—	1·5	45	9	4	6	16	24
Totals	—	—	624	48	7	2	—	—	96	480	—	894	8900	3050	5780	80	604	342	50	4440	38·6	105	264	14	1093·7	2647	5294	52	66	174	261
If Main Office is to be constructed in Wood	Deduct.	—	—	—	7	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Add.	—	—	—	—	—	—	—	—	—	1190	—	830	10	100	130	176	64	—	3500	—	—	—	—	—	—	—	6	12	12	48
Vehicle Reception Depot																															
1. Equipment Store.	72'x240'	1	32	4	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	70	—	36	107	214	—	—	—	—
2. Workshops.	72'x240'	1	—	—	—	—	32	4	12	—	—	—	—	—	—	—	—	—	—	—	—	—	62	—	36	107	214	—	—	—	—
3. Car Shelter.	72'x240'	1	32	4	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	70	—	36	107	214	—	—	—	—
4. Cycle Shelter.	36'x120'	1	8	2	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	16	—	13	40	80	—	—	—	—
5. Petrol Store.	72'x75'	1	10	4	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	30	—	11·3	33·3	66·6	—	—	—	—
6. Paint Store.	36'x30'	1	2	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	9	—	2·3	6·7	13·4	—	—	—	—
7. Fire Station.	36'x20'	1	—	—	—	—	—	—	—	—	—	170	870	440	490	40	12	56	7	1100	—	—	—	—	1·5	45	9	4	6	16	24
8. Police Hut.	36'x20'	1	—	—	—	—	—	—	—	120	—	170	1590	480	490	40	12	56	7	1100	8	22	8	2	—	—	—	6	8	22	33
9. Main Office.	28'x85'	1	—	—	5	2	—	—	—	250	—	70	1840	560	1160	—	—	—	—	—	20	58	20	8	—	—	—	12	15	36	56
10. I.M.T. Office.	30'x20'	1	—	—	—	—	—	—	—	120	—	180	820	400	450	44	—	48	6	1000	7	11	4	2	—	—	—	5	6	9	28
Totals	—	—	84	16	5	2	32	4	25	490	—	600	5220	1880	2590	124	24	160	20	3200	35	91	289	12	136·1	405·5	811	27	35	83	141
If Main Office is to be constructed in Wood	Deduct	—	—	—	5	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Add	—	—	—	—	—	—	—	—	—	800	—	560	—	90	90	120	40	—	2500	—	—	—	—	—	—	—	5	7	14	20
Base M.T. Stores Depot																															
1. Store Sheds	72'x120'	20	320	80	—	—	—	—	40	—	—	—	—	—	—	—	—	—	—	—	—	—	320	—	360	1,067	2,134	—	—	—	—
2. Paint Store.	36'x120'	1	8	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	21	—	9	27	54	—	—	—	—
3. Workshops.	72'x120'	3	—	—	—	—	48	12	12	—	—	—	—	—	—	—	—	—	—	—	—	—	120	—	54	160	320	—	—	—	—
4. Receipt and Issue.	72'x180'	2	48	8	—	—	—	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	64	—	54	160	320	—	—	—	—
5. Office Blocks.	28'x120'	3	—	—	27	6	—	—	—	1440	—	335	11280	3300	6600	—	—	—	—	—	105	360	42	30	—	—	—	80	100	250	400
If Main Office is to be constructed in Wood	Deduct	—	—	—	27	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Add	—	—	—	—	—	—	—	—	—	4760	—	3120	—	600	530	700	256	—	13000	—	—	—	—	—	—	—	16	20	38	40
Ordnance Stores																															
1. Store Sheds.	108'x380'	8	552	96	—	—	—	—	64	—	—	—	—	—	—	—	—	—	—	—	—	—	200	—	680	2000	4000	—	—	—	—
2. Oil Store.	40'x25'	1	—	—	—	—	—	—	—	70	—	50	440	620	580	100	—	150	8	1600	—	—	4	1	2·1	6·2	12·4	5	7	20	24
3. Inflammable Store.	25'x20'	1	—	—	—	—	—	—	—	100	—	160	180	330	330	40	—	43	6	1100	—	—	3	1	1·1	3·2	6·4	3	5	8	25
4. Acid Store.	30'x10'	1	—	—	—	—	—	—	—	—	—	70	440	240	470	—	360	—	7	420	—	—	4	1	·7	2	4	2	4	10	16
5. Guard, etc.	2500 F.S.	5	—	—	—	—	—	—	—	375	—	640	5124	1830	2000	130	488	166	31	4680	29	56	18	7	—	—	—	22	31	80	120
6. Traffic Offices etc.	1620 F.S.	3	—	—	—	—	—	—	—	270	—	300	3215	1100	1170	90	21	129	18	2390	18	28	12	4	—	—	—	18	19	48	71
7. Main Offices.	13800 F.S.	3	—	—	39	6	—	—	—	1640	—	526	15210	4560	2230	—	—	—	—	—	143	477	72	30	—	—	—	85	101	244	356
Totals.	—	—	552	96	39	6	—	—	64	2455	—	1746	10608	9680	3790	360	869	488	70	10190	190	561	313	44	683·9	2011·4	4022·8	142	167	410	612
If Main Offices are to be constructed in Wood	Deduct	—	—	—	39	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Add	—	—	—	—	—	—	—	—	—	7026	94	4270	396	2070	619	902	303	—	19,000	—	—	—	—	—	—	—	28	53	128	204
Returned Stores Depot.																															
1. Store Sheds.	65000 F.S.	4	120	24	—	—	—	—	24	—	—	—	—	—	—	—	—	—	—	—	—	—	80	—	193	572	1144	—	—	—	—
2. Office.	28'x30'	1	—	—	2	2	—	—	—	120	—	34	920	280	600	—	—	—	—	—	9	28	14	6	—	—	—	6	7	14	20
Totals.	—	—	120	24	2	2	—	—	24	120	—	34	920	280	600	—	—	—	—	—	9	28	94	6	193	572	1144	6	7	14	20
If Office is to be constructed in Wood	Deduct	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Add	—	—	—	—	—	—	—	—	—	400	—	280	—	100	44	60	20	—	1200	—	—	—	—	—	—	—	2	3	10	16
Engineer Stores Depot																															
1. Store Sheds.	58450 F.S.	4	108	24	—	—	—	—	24	—	—	—	—	—	—	—	—	—	—	—	—	—	72	—	174	514	1028	—	—	—	—
2. Offices.	4000 F.S.	2	—	—	10	4	—	—	—	510	—	150	4430	1210	2550	—	—	—	—	—	43	108	36	14	—	—	—	25	30	63	96
3. Latrines.	21'x18'	2	—	—	—	—	—	—	—	—	—	185	245	335	920	—	110	115	8	320	2	—	—	—	1·6	4·8	9·6	7	9	24	36
4. Ablution Sheds.	36'x12'	2	—	—	—	—	—	—	—	—	—	92	590	320	630	—	180	—	14	150	—	—	4	2	1·0	1·4	3·2	6	8	24	36
Totals	—	—	108	24	10	4	—	—	24	510	—	427	5265	1865	4100	—	290	115	22	470	45	108	112	16	176·6	520·2	1040·8	38	47	111	168
If Offices are to be constructed in Wood	Deduct	—	—	—	10	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Add.	—	—	—	—	—	—	—	—	—	1950	—	1020	250	310	192	270	94	—	4800	—	—	—	—	—	—	—	13	17	47	68
Transportation Stores Depot.																															
1. Store Sheds.	52500 F.S.	7	98	28	—	—	—	—	42	—	—	—	—	—	—	—	—	—	—	—	—	—	168	—	158	467	934	—	—	—	—
2. Workshop.	36'x105'	1	—	—	—	—	7	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	12	—	11·3	33·3	66·6	—	—	—	—
3. Office.	28'x77'	1	—	—	6	2	—	—	—	340	—	90	2460	738	1500	—	—	—	—	—	23	75	20	8	—	—	—	15	16	36	54
4. Latrines.	21'x18'	2	—	—	—	—	—	—	—	—	—	185	245	335	920	—	110	115	8	320	2	—	—	—	1·6	4·8	9·6	7	9	24	36
5. Ablution Sheds.	36'x12'	2	—	—	—	—	—	—	—	—	—	92	590	320	630	—	180	—	14	150	—	—	4	2	1·0	1·4	3·2	6	8	24	36
Totals	—	—	98	28	6	2	7	2	44	340	—	367	3295	1393	3050	—	290	115	22	470	25	75	204	—	171·9	506·5	1013·4	28	33	84	126
If Office is to be constructed in Wood	Deduct	—	—	—	6	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Add	—	—	—	—	—	—	—	—	—	1160	—	840	52	100	120	155	60	—	3300	—	—	—	—	—	—	—	7	12	32	46
Ammunition Depot											9"x3"	6"x3"	7"x2"	4"x2"	3"x2"																
1. Heavy Sheds.	300'x30'	10	—	—	—	—	—	—	—	—	14300	21700	1100	1700	6600	—	9900	—	660	—	—	—	—	—	92·5	3130	2710	1600	2200	2800	4400
2. Heavy Sheds.	100'x30'	4	—	—	—	—	—	—	—	—	13240	3000	150	680	880	—	1320	—	88	—	—	—	—	—	12·3	416	360	200	280	360	560
3. Sheds.	20'x30'	4	—	—	—	—	—	—	—	—	3848	580	32	480	88	—	264	—	32	—	—	—	—	—	2·5	84	72	40	56	72	112
4. Sheds.	16'x25'	32	—	—	—	—	—	—	—	—	13856	9280	171	2560	795	—	1408	—	171	—	—	—	—	—	14	448	384	1080	1470	1920	2900
Totals	—	—	—	—	—	—	—	—	—	—	181244	34560	1453	5420	8363	—	12892	—	951	—	—	—	—	—	121·3	4078	3526	2920	400	3152	7972

NOTE.

For details of Standard Steel and C.I. Store Sheds, 36' span, see Plate 25
" " " " " " " " " 28' " " " 25
" " " " " " " Workshops 36' " " " 107

Following Appendix IX

A ENDIX X

LIST OF MATERIALS REQUIRED … CONSTRUCTION OF VARIOUS BASE WORKSHOPS.

Description	Size	Number	Standard Steel & C.I. Store Sheds 36' Span Bays	36' Span Ends	28' Span Bays	28' Span Ends	Workshops 36' Span Bays	Workshops 36' Span Ends	Roller Shutters	Tim… 8"×1"	6…
R.A.S.C. Heavy Repair Shop											
1. Workshops. Total	132500 F.S.	6	—	—	—	—	256	34	28	—	-
2. Stores. "	12,000 F.S.	1	22	4	—	—	—	—	2	—	-
3. Offices. "	4,000 F.S.	2	—	—	11	2	—	—	—	600	-
Totals.	—	—	22	4	11	2	256	34	30	600	-
If offices are to be constructed in wood.	Deduct	—	—	—	11	2	—	—	—	—	-
	Add	—	—	—	—	—	—	—	—	—	19…
Ordnance Workshops											
1. Main Shops. each	395'×144'	6	—	—	—	—	624	48	96	—	-
2 " " "	289'×144'	2	—	—	—	—	152	16	28	—	-
3. " " "	395'×72'	2	—	—	—	—	104	8	28	—	-
4. Instrument Shop "	289'×36'	1	—	—	—	—	19	2	6	—	-
5. Oil Store. "	36'×30'	1	2	2	—	—	—	—	1	—	-
6. Electrical Shop "	199'×36'	1	—	—	—	—	13	2	4	—	-
7. Offices. "	100'×28'	2	—	—	16	4	—	—	—	1160	-
8. Petrol Store. "	36'×30'	1	2	2	—	—	—	—	1	—	-
9. Latrines. "	21'×18'	3	—	—	—	—	—	—	—	—	-
10. Ablution Sheds "	36'×12'	3	—	—	—	—	—	—	—	—	-
Totals	—	—	4	4	16	4	912	76	164	1160	-
If offices are to be constructed in wood	Deduct	—	—	—	16	4	—	—	—	—	-
	Add	—	—	—	—	—	—	—	—	—	29…
Engineer Workshops											
1. Workshops. Total	75,600 F.S.	3	—	—	—	—	152	16	24	—	-
2. Sawmill. each.	36'×150'	1	—	—	—	—	10	2	2	—	-
3. Offices. "	28'×74'	1	—	—	6	2	—	—	—	210	-
4. Power House. "	36'×60'	1	—	—	—	—	4	2	1	—	-
5. Latrines. "	21'×18'	2	—	—	—	—	—	—	—	—	-
6. Ablution Sheds "	36'×12'	2	—	—	—	—	—	—	—	—	-
Totals.	—	—	—	—	6	2	166	20	27	210	-
If offices are to be constructed in wood	Deduct		—	—	6	2	—	—	—	—	-
	Add		—	—	—	—	—	—	—	—	104…
Transportation Workshops											
1. Machine Shop each	240'×72'	1	—	—	—	—	32	4	10	—	-
2. Various Workshops Total.	28,600 F.S.	8	—	—	—	—	53	16	20	—	-
3. Power House. each.	105'×72'	1	—	—	—	—	4	4	4	—	-
4. Stores. "	23,800 F.S.	2	44	8	—	—	—	—	8	—	-
5. Offices. "	28'×90'	1	—	—	7	2	—	—	—	360	-
6. Latrines. "	21'×18'	4	—	—	—	—	—	—	—	—	-
7. Ablution Sheds. "	36'×12'	4	—	—	—	—	—	—	—	—	-
Totals.	—	—	44	8	7	2	89	24	42	360	-

Description	Ft. Run 4"×2"	3"×3"	3"×2"	G.C.I. Sheets 9'0"	7'6"	6'0"	Ridging 6'0	Galv. Screws & Washers	Boarding (Squares)	Inner Lining (Squares)	Windows	Doors	Concrete Cement Tons.	Sand Yds. C.	Agg^te Yds. C.	Nails (lbs) 6"	5"	4"	2½"
R.A.S.C. Heavy Repair Shop																			
1. Workshops.	—	—	—	—	—	—	—	—	—	—	228	—	379	1295	2590	—	—	—	—
2. Stores.	—	—	—	—	—	—	—	—	—	—	20	—	36	180	360	—	—	—	—
3. Offices.	4620	1200	2800	—	—	—	—	—	41	130	28	12	—	—	—	27	30	70	100
Totals.	4620	1200	2800	—	—	—	—	—	41	130	276	12	415	1475	2950	27	30	70	100
If offices … Deduct	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Add	1380	180	200	220	280	110	—	5,800	—	—	—	—	—	—	—	13	20	50	80
Ordnance Workshops																			
1. Main Shops.	—	—	—	—	—	—	—	—	—	—	336	—	1000	2978	5956	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—	96	—	245	428	856	—	—	—	—
3.	—	—	—	—	—	—	—	—	—	—	104	—	500	1482	2964	—	—	—	—
4. Instrument Shop	—	—	—	—	—	—	—	—	—	—	34	—	31	90	180	—	—	—	—
5. Oil Store.	—	—	—	—	—	—	—	—	—	—	3	—	3·3	9	18	—	—	—	—
6. Electrical Shop	—	—	—	—	—	—	—	—	—	—	24	—	21	62	124	—	—	—	—
7. Offices.	6180	1820	3400	—	—	—	—	—	60	184	40	16	—	—	—	36	45	95	140
8. Petrol Store.	—	—	—	—	—	—	—	—	—	—	3	—	3·3	9	18	—	—	—	—
9. Latrines.	368	503	1380	—	165	173	12	480	3	—	—	—	2·4	7·2	14·4	11	14	36	54
10. Ablution Sheds	385	480	945	—	270	—	21	225	—	—	6	3	·8	1·1	2·2	9	12	36	54
Totals	433	2803	5725	—	435	173	3	705	63	184	646	19	1806·8	5066·3	10132·6	56	71	167	248
If offices … Deduct	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Add	620	240	320	224	352	110	—	8800	—	—	—	—	—	—	—	12	15	49	76
Engineer Workshops																			
1. Workshops.	—	—	—	—	—	—	—	—	—	—	94	—	251	856	1710	—	—	—	—
2. Sawmill.	—	—	—	—	—	—	—	—	—	—	20	—	16	47·4	94·8	—	—	—	—
3. Offices.	430	700	1500	—	—	—	—	—	21	75	20	8	—	—	—	12	15	30	48
4. Power House.	—	—	—	—	—	—	—	—	—	—	9	—	6·5	20	40	—	—	—	—
5. Latrines.	245	335	920	—	110	115	8	320	2	—	—	—	1·6	4·8	9·6	7	9	24	36
6. Ablution Sheds	590	320	630	—	180	—	14	150	—	—	4	2	·5	·8	1·6	6	8	24	36
Totals.	265	1355	3050	—	290	115	22	470	23	75	147	10	275·6	929	1856	25	32	78	120
If offices … Deduct	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Add	00	80	150	80	123	40	—	3000	—	—	—	—	—	—	—	5	6	20	28
Transportation Workshops																			
1. Machine Shop	—	—	—	—	—	—	—	—	—	—	58	—	36	107	214	—	—	—	—
2. Various Workshops	—	—	—	—	—	—	—	—	—	—	118	—	85	252	504	—	—	—	—
3. Power House.	—	—	—	—	—	—	—	—	—	—	22	—	34	100	200	—	—	—	—
4. Stores.	—	—	—	—	—	—	—	—	—	—	60	—	106	315	630	—	—	—	—
5. Offices.	770	820	1700	—	—	—	—	—	27	83	20	8	—	—	—	16	18	40	60
6. Latrines.	190	670	1840	—	220	230	16	640	4	—	—	—	3·2	9·6	19·2	14	18	48	72
7. Ablution Sheds.	80	640	1260	—	360	—	28	300	—	—	8	4	1	1·4	2·8	12	16	48	72
Totals.	540	2130	4800	—	580	230	44	940	31	83	286	12	265·2	785	1570	42	52	136	204

Description	Size	Number	Steel B.S.B.'s 22"×7"	12"×8"	8"×4"	7"×4"	Steel Channels 15"×4"	Steel Angles 6"×6"×½"	6"×3"×⅜"	4"×4"×⅜"	3"×3"×…
8. Erecting and Boiler Shops. Total	18,720 f.s.	2.									
Totals.			2340.	3888	2304.	5400	3240	2376	3240	8568	2577…

…Plates …×¾"	12"×½"	G.C. Sheets 7'0"	Hook Bolts	Found^n Bolts	Sheeting Bolts Nuts & Washers	Flat Bottom Rails	B.R.C. No. 8 Fabric	Concrete Cement	Sand	Agg^te	Wood Paving
56	1440	8100	20736	216	129,600.	2880	3600 S.Yds	39 Tons	116 Y.C.	232 Y.C.	162 Sq.

APPENDIX XII

TIMBER PRODUCTION—STATISTICAL RECORDS

Specimen report headings

1. *Daily report of forest working party*

FOREST NAME .... WEATHER ....

WORKING SECTION .... DATE..

Logs felled.			(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) No. A*	(2) Length ft.	(3) Q.G. centre.	Contents cu. ft. B*	Logs cross-cut to length.	Fascines made.	Poles.	Pickets.	Hurdles.	Spare column.	Remarks.
										Information as to time required to get various items to rail, etc., where track might be laid with advantage, etc.

* A.—Rotation number given to each log.

* B.—Contents calculated in the office from Q.G. (quarter-girth) × length. (Hoppus' tables.)

Logs cross-cut, *i.e.* lengths to which logs are cross-cut so that the O. i/c may know what stock of various lengths he has and give instructions accordingly.

Sub-columns under Poles, Pickets, and Hurdles are for the various specifications (Appendix XIV.).

2. *Daily report of saw-mill*

MILL NAME .... DATE ....

Sleepers.		(3) Crossings.	(4) Mining sets.	(5) Hutting.	(6) Specifications cut.	(7) Stock of logs yesterday.	(8) No.
(1) p.c.s.	(2) cu. ft.						
						Logs cut	
						Logs received	
						In stock	

3. *Daily report from dump at*..................

DATE...................

(1)	(2) Sawn.	(3) Brushwood.	(4) Notation No. given.	(5) Remarks.
	Specifications.	Specifications.		
Stock yesterday ...				
Stock issued				
Stock received ...				
In stock				

APPENDIX XIII

LIST OF MACHINERY AND STORES REQUIRED FOR FOREST EXPLOITATION

(Referred to in Sec. **140**)

A. Saw-mill machinery

One friction feed breaking down bench, complete to take 60-in. saw, with mechanical device to hold log on carriage.

One re-saw bench, 36-in.

One re-saw bench, 48-in.

One pendulum cross cut.

One gulletting machine.

One engine, steam, portable, 80/100 h.p.

One 10-b.h.p. petrol engine.

One lighting set with power for counter-shafts, pulleys, and belting as required for lay-out of saw-mill.

One pump and petrol engine, if required.

Note.—If possible, a portable mill should have one spare portable engine and one spare 48-in saw-bench. This could be used to go on detachment if necessary.

The number of re-saw benches required depends on the quantities of hutting and similar timber which it is anticipated will have to be re-sawn from planks.

B. Saw-mill tools and stores

Anvils, B/S., 1 cwt.	1
,, Blocks	1
Asbestos sheets	12
Augers, $1\frac{1}{4}$-in., 1-in., $\frac{7}{8}$-in., $\frac{3}{4}$-in., $\frac{1}{2}$-in., $\frac{1}{4}$-in.	1 of each
Bars, crow	2
,, pinch	6
Beltine	1 cwt.
Belting, 8-in.	100 ft.
,, 7 ,,	200 ,,
,, 6 ,,	80 ,,
,, 4 ,,	100 ,,
,, 1 ,,	50 ,,
Bends, pipe, 1-in.	12
,, ,, 2 ,,	18
,, ,, $2\frac{1}{2}$,,	6
Blocks, chain, endless, 1 ton	1

2. *Daily report of saw-mill*

MILL NAME .... DATE ....

Sleepers. (1) p.c.s.	Sleepers. (2) cu. ft.	(3) Crossings.	(4) Mining sets.	(5) Hutting.	(6) Specifications cut.	(7) Stock of logs yesterday.	(8) No.
						Logs cut	
						Logs received	
						In stock	

3. *Daily report from dump at* ....

DATE ....

(1)	(2) Sawn. Specifications.	(3) Brushwood. Specifications.	(4) Notation No. given.	(5) Remarks.
Stock yesterday ...				
Stock issued ...				
Stock received ...				
In stock ...				

APPENDIX XIII

LIST OF MACHINERY AND STORES REQUIRED FOR FOREST EXPLOITATION

(Referred to in Sec. 140)

A. Saw-mill machinery

One friction feed breaking down bench, complete to take 60-in. saw, with mechanical device to hold log on carriage.

One re-saw bench, 36-in.

One re-saw bench, 48-in.

One pendulum cross cut.

One gulletting machine.

One engine, steam, portable, 80/100 h.p.

One 10-b.h.p. petrol engine.

One lighting set with power for counter-shafts, pulleys, and belting as required for lay-out of saw-mill.

One pump and petrol engine, if required.

Note.—If possible, a portable mill should have one spare portable engine and one spare 48-in saw-bench. This could be used to go on detachment if necessary.

The number of re-saw benches required depends on the quantities of hutting and similar timber which it is anticipated will have to be re-sawn from planks.

B. Saw-mill tools and stores

Anvils, B/S., 1 cwt.	1
,, Blocks	1
Asbestos sheets	12
Augers, $1\frac{1}{4}$-in., 1-in., $\frac{7}{8}$-in., $\frac{3}{4}$-in., $\frac{1}{2}$-in., $\frac{1}{4}$-in. ...	1 of each
Bars, crow	2
,, pinch	6
Beltine	1 cwt.
Belting, 8-in.	100 ft.
,, 7 ,, ...	200 ,,
,, 6 ,, ...	80 ,,
,, 4 ,, ...	100 ,,
,, 1 ,, ...	50 ,,
Bends, pipe, 1-in.	12
,, ,, 2 ,, ...	18
,, ,, $2\frac{1}{2}$,, ...	6
Blocks, chain, endless, 1 ton	1

2. *Daily report of saw-mill*

MILL NAME .... DATE ....

Sleepers.		(3) Crossings.	(4) Mining sets.	(5) Hutting.	(6) Specifications cut.	(7) Stock of logs yesterday.	(8) No.
(1) p.c.s.	(2) cu. ft.						
						Logs cut	
						Logs received	
						In stock	

3. *Daily report from dump at*..................

DATE...................

(1)	(2) Sawn.	(3) Brushwood.	(4) Notation No. given.	(5) Remarks.
	Specifications.	Specifications.		
Stock yesterday ...				
Stock issued				
Stock received ...				
In stock				

APPENDIX XIII

LIST OF MACHINERY AND STORES REQUIRED FOR FOREST EXPLOITATION

(Referred to in Sec. **140**)

A. Saw-mill machinery

One friction feed breaking down bench, complete to take 60-in. saw, with mechanical device to hold log on carriage.

One re-saw bench, 36-in.

One re-saw bench, 48-in.

One pendulum cross cut.

One gulletting machine.

One engine, steam, portable, 80/100 h.p.

One 10-b.h.p. petrol engine.

One lighting set with power for counter-shafts, pulleys, and belting as required for lay-out of saw-mill.

One pump and petrol engine, if required.

Note.—If possible, a portable mill should have one spare portable engine and one spare 48-in saw-bench. This could be used to go on detachment if necessary.

The number of re-saw benches required depends on the quantities of hutting and similar timber which it is anticipated will have to be re-sawn from planks.

B. Saw-mill tools and stores

Anvils, B/S., 1 cwt.	1
,, Blocks	1
Asbestos sheets	12
Augers, $1\frac{1}{4}$-in., 1-in., $\frac{7}{8}$-in., $\frac{3}{4}$-in., $\frac{1}{2}$-in., $\frac{1}{4}$-in.	1 of each
Bars, crow	2
,, pinch	6
Beltine	1 cwt.
Belting, 8-in.	100 ft.
,, 7 ,,	200 ,,
,, 6 ,,	80 ,,
,, 4 ,,	100 ,,
,, 1 ,,	50 ,,
Bends, pipe, 1-in.	12
,, ,, 2 ,,	18
,, ,, $2\frac{1}{2}$,,	6
Blocks, chain, endless, 1 ton	1

B. Saw-mill tools and stores—*continued*

Borax	1 lb.
Bolts and nuts assorted, about	144
Brushes, tube boiler	6
Cable, steel, 1½-in. circular	200 ft.
Cant hooks	24
Cases, oil, S.F. ½-pint	6
,, ,, ,, 1 ,, ...	4
Carpenters' tool chest	1
Cells, dry	6
Chalk, boxes	2
Chests, tool, B/S, filled	1
Cleats, porcelain (for carrying lighting wires) ...	288
Cloth, emery, sheets	36
Cocks, 2-in., water, one way	8
Composition, boilers	20 lb.
Copper tube	6 per engine
Cramps, carpenters'	2
Cutters, pipe, 2-in.	1
,, ,, 1 ,, ...	1
Edges, straight, 36-in.	1
,, ,, 24 ,, ...	2
Elbows, pipe, 2-in.	12
,, ,, 1 ,, ...	12
Extinguishers, fire	36
,, ,, refills	48
Fasteners, belt, assorted	144
Felt, tarred, rolls	8
Files, fitters, assorted	36
Files, saw sharpeners, assorted	288
Flanges, pipe, 2-in.	4
,, ,, 1 ,, ...	4
Fluxite, soldering tins	2
Forge	1
Gaskets, engine, assorted	60
Glasses, gauge, assorted	48
Graphite	5 lb.
Grindstones, power complete	2
Hammers, claw	12
,, 2-lb.	6
Hasps, padlock	6
Hemp	1 bale
Hinges	12

B. Saw-mill tools and stores—*continued*

Irons, soldering	2
Jointite	2 tins
Ladles, melting, 3-pint	1
Lamps, blow, 1-pint	1
Levels, spirit, 6-in.	2
Lines, carpenters	4
Locks, box	4
Mallets, carpenters	4
Metal, babbitt	20 lb.
Nails, assorted	1 cwt.
Nipples, pipe, 2-in.	6
„ „ 1 „	6
Oil, hurricane lamp	12
Paper, friction	4 sheets
Pencils, carpenters'	144
Pincers, carpenters'	2
Piping water, 2-in.	200 ft.
„ „ 1 „	100 „
„ plugs, 2-in.	4
„ „ 1 „	4
Pliers, side cutting	2
„ gas	2
Plugs, sparking	6
Red lead	10 lb.
Rope, manilla, 4-in.	250 ft.
„ „ 3 „	250 „
„ white, 1½-in.	200 „
Rules, steel, A.A., 24-in.	4
Reducing sockets, 2-in. to 1-in.	12
Saws, circular, rip, 60-in.	2
„ „ „ „ inserted teeth ...	2
„ „ cross cut, 24-in.	4
„ „ rip, 48-in. inserted teeth ...	3
„ „ 48-in. inserted teeth	3
„ „ 48-in. to 60-in.	3
„ „ 36-in. to 48-in.	3
„ „ 36-in.	4
„ „ 36-in. or under	6

B. Saw-mill tools and stores—*continued*

Saws, swage, setters, Ransomes	6
„ hack	2
„ „ blades	48
Saw teeth—bits	288
„ „ —holding shanks	48
„ „ —spanners	4
Screwdrivers, 14-in.	2
„ 12 „	4
„ 6 „	8
Screws, wood, assorted	288
Shears, tinman's, snip	2
Spanners, assorted	24
„ shifting	4
Sockets, pipe, 2-in. and 1-in.	12
Solder, silver	4 lb.
„ tinman's	10 „
Spirits of salts	1 pint.
Steel, tool, assorted	4 bars
„ mild, assorted	12 „
Stocks and dies, Whitworth	1 set
Switches, electric	6
Saw, hammering, set	1
Tape, adhesive	4 lb.
Tacks, tin for felt	5 „
Tape measures, 100-ft. and 50-ft.	1 each
Tape, asbestos	20 lb.
Tees, pipe, 2-in.	4
„ „ 1 „	4
„ „ 2-in. and 1-in. reducing	12
Taps, gas	1 set
„ Whitworth	1 „
Tank, water, 1,000-gal.	1
„ „ 40 „	6
Taps, water, 1-in.	8
Tarpaulins	4
White lead	10 lb.
Wrenches, pipe	4
Wheels, emery, assorted	24
Waste	1 cwt.
Wire, lighting	2,000/500 yds.
„ telephone	2 miles
„ fuse	10 lb.

C. List of tools

For working party in the forest

Axes, felling, heads	100
„ „ helves	150
„ hand, heads	16
„ „ helves	19
„ pick, heads	12
„ „ helves	18
Adze, heads	12
„ helves	18
Blocks, snatch, 2-in.	6
Cans, oil, ½-pint	4
Cant hooks	48
„ „ handles	60
Chain, logging, ⅜-in. or ½-in. link	100 ft.
„ harness, ¼-in. link	150 „
Cutters, wire	48
Decauville track with points, etc.	as required
Dogs, logging	24
Grease, axle	1 cwt.
Grindstones, hand, 36-in.	4
Hammers, sledge, 10-lb.	48
„ „ 7 „	24
„ hand, 2-lb.	6
Hooks, bill	50
Hones for sharpening axes, etc.	100
Lamps, oil, hurricane	44
Paint, red oxide or other C	40 lb.
Paint brushes	4
Petrol tractors for Decauville	1 per mile (average)
Rules, G.S., 4 fold, 24-in.	6
Rope, wire, 1½-in. to 2½-in. circumference	150 ft.
„ manilla, 3-in.	200 „

C. List of tools—*continued*

Saws, cross cut, 7-ft.	12
,, ,, ,, 6 ,, ...	24
,, ,, ,, 5 ,, ...	48
,, ,, ,, 3 ,, ...	24
Saw handles	750
Saws, sets, hand	4
Saw files, taper	72
Shovels, R.E.	24
Sloops for hauling logs to railway	20
Spanners, double ended, $\frac{7}{16}$-in.	18
,, ,, ,, $\frac{5}{16}$-in.	18
Split rings for logging, and chain	100
Tapes, measures, blue chalk, etc.	as required
Trucks	10 per mile (average)
Wedges, splitting, 10-in.	48
,, ,, 8 ,, ...	60
,, ,, 10 ,, ...	48

APPENDIX XIV

TYPICAL SAWING INSTRUCTIONS

1. **Logging.**—Felled trees should not be cross-cut into logs before it is absolutely necessary for the progress of the work.

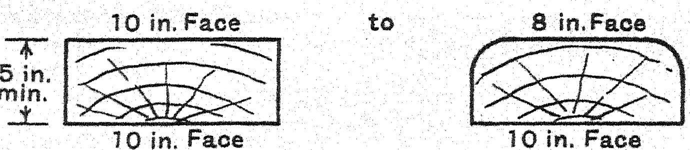
The normal cross-cutting should not be more than a week ahead of conversion in the mill.

Military requirements will always vary and consequently lengths other than those specified at the moment may be subsequently required.

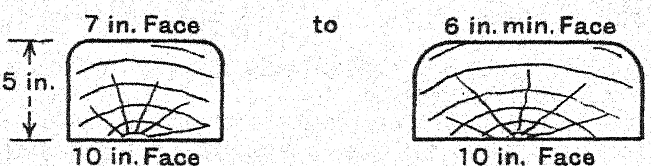
All cross-cutting into logs should be done under close supervision, and with a clear understanding of the specifications attached.

2. **Standard gauge sleepers.**—Class I.—Species: all softwoods and oak—beech up to 20 per cent. (maximum). Dimensions: length, 9 ft.; width of bottom, 9 in. to 10½ in.; width of top face, 8 in. minimum; depth, 5 in. minimum.

Permissible wane not more than 1 in. on either edge, but the minimum upper face of 8 in. must remain.



Class II.—Species: all softwoods and oak or beech. Dimensions: length 9 ft.; width of bottom, 9 in. to 10½ in.; width of top face, 6 in. minimum; depth, 5 in.—permissible variation ½ in. Permissible wane not more than 2 in. on either edge, but the minimum upper face of 6 in. must remain.

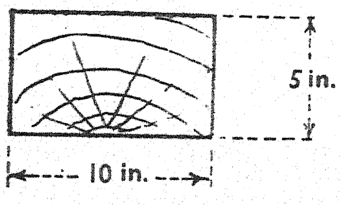


To be piled in two separate piles according to class. The different species of timber (softwood, oak and beech) also to be piled separately and despatched in separate trucks.

3. **Standard gauge crossing sleepers.** (Crossing sleepers).—

Species: all softwoods and oak. Dimensions: 5 in. by 10 in.—14 ft. long. To be cut ⅛ in. over size.

Crossing sleepers should be without any wane whatever.



4. **Sixty centimetre gauge sleepers.** (60 cm. sleepers).—

Species: all softwoods, oak and beech. Length: not less than 4 ft. 6 in. (minimum).

Permissible variation.—Bottom width, 6 in. to 7½ in. in 7-in. sleepers and 7½ in. to 8½ in. in 8-in. sleepers. Top width: sleepers must have a minimum upper face of 6 in. Wane: the maximum wane on either edge to be in the 4-in. by 7-in. sleepers—½ in., 4-in. by 8-in. sleepers—1 in., still giving the minimum 6-in. upper face.

5. **Metre gauge sleepers.**—Species: pine or other softwoods, oak and beech. Dimensions: length of sleepers, 6 ft. 6 in.; thickness, 4½ in. (minimum); width of upper face, 5 in. (minimum); width of bottom side of sleepers 7½ in. to 8½ in.

Can be made by splitting poles with the saw in the mill. The poles to be surfaced on two sides and then split.

6. **Road slabs.**—Species: hardwoods, including such oak as is not suitable for conversion to other material. Dimensions: thickness must be 2½ in. (sawn ⅛ in. over size); length, 10 ft.; 20 per cent. may be 9 ft.

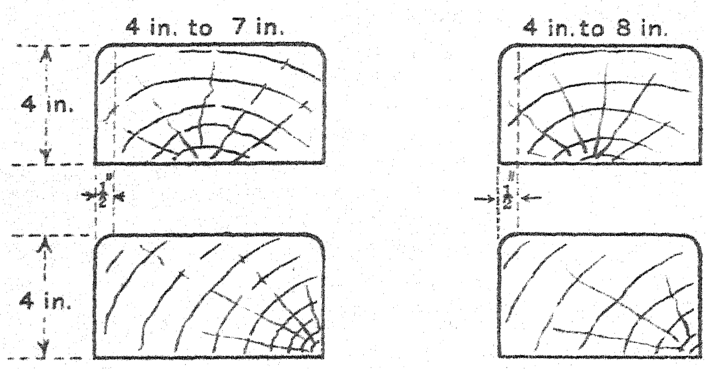
20 per cent. may be 9 ft. 9 in. and up in hardwood logs and oak as above, to be sawn into road slabs and in the largest width obtainable from logs available, and may have waney edges.

Slabs over 20 in. in width should be sawn in half longitudinally to make two slabs.

If a log will produce one or more standard gauge sleepers with one or more 2½-in. slabs, it should be cut 9-ft. length and produce standard gauge sleepers and road slabs all 9 ft. long.

Oak logs large enough should be converted into standard gauge sleepers.

7. **4-in. road planks.**—Species: hardwoods, including such oak as is not suitable for conversion to other material. Dimensions: thickness, 4 in.; length, 9 ft.



9-in. and up hardwood logs (and oak as above) to be sawn into road planks and in the largest width obtainable from logs available, **but planking must be edged square.**

Planks over 20 in. in width should be sawn in half longitudinally to make two planks.

Oak logs large enough should be converted into standard gauge sleepers.

8. **Sawn defence timber.**—Species: softwoods. Dimensions: length, 3 ft. and up, and longest average length possible.

All sawn defence timber must be edged square and sawn into the following categories:—

Group.	*Thickness.*	*Width.*	
B	3 in.	3 in. and up.	widest average possible.
C	2 in.	2 in. ,,	
D	1½ in.	3 in. ,,	
E	1 in.	3 in. ,,	
J	All boards under 1-in. thickness.		

Each group to be piled separately and despatched in separate trucks.

Boards 1½ in., 1 in. and under 1 in. in thickness not to be specially produced, only as falling from the saw.

9. **Hardwood boarding.**—Species: hardwoods. Dimensions: length, 3 ft. and up; width, 5 in. and wider; thickness, 1 in. and 1½ in. only. **Must be edged square.**

This should only be produced as necessary from the side cuts made in the sawing of sleepers, 2½-in. mining timber and road slabs.

Only exceptional cases or special instructions will warrant logs being wholly converted into this product.

10. *Offcuts.*	*Classification.*
Class (1).	$2\frac{1}{2}$ in. and up thick at the thin end, 9 ft. and up long, to be despatched with **road slabs or split poles.**
,, (2).	$1\frac{1}{2}$ in. to $2\frac{1}{4}$ in. thick at the thin end, 6 ft. and up long, to be despatched **for stabling.**
,, (3).	1 in. to $1\frac{1}{4}$ in. thick at the thin end, 3 ft. and up long, suitable for re-sawing, but this class to be re-sawn at the mill as far as possible, and any surplus to be piled ready for despatch when required.
,, (4).	Slabs and offcuts any length, suitable only for fuel, to be piled together for that purpose.

11. Poles and pickets.—*Classification.*

Letter.	Description. Poles round.	Length.	Diameter at tip.	Primary use.	Remarks.
O.	Stout	13 ft.	Over 6 in. up to 9 in.	Uprights of heavy buildings.	Soft or hardwood.
P.	Medium	13 ft. 6 in.	Over 3 in. up to 6 in.	Uprights and rafters of buildings, etc.	Hardwood.
Q.	Medium	10 ft.	Over 4 in. up to 6 in.	Roads.	Soft or hardwood. Must be **straight.**
R.	Medium	10 ft.	do.	Uprights of buildings and dug-outs.	Soft or hardwood.
S.	Medium	6 ft. 6 in.	Over 4½in. up to 6½ in.	Uprights of dug-outs.	do.
U.	Thin	12 ft.	2½ in. to 4 in.	Screens.	Hardwood.
W.	Thin	6 ft. and to 8 ft.	2½ in. to 4 in.	Revetments.	Hardwood.
X.	Poles ½-rd. (stout)	10 ft.	From poles over 5½ in. and up to 7 in.	Roads.	Soft or hardwood. Must be **straight.** To be split with the saw in mill.

Pickets. Under 6-ft., various. Not to be made unless specially ordered.

Each category to be piled separately and to be despatched in separate trucks.

12. **Telegraph poles.**—

i. "A" size—pine or larch. Sound, straight and free from large branch knots.

Specification.

Length.	Maximum and minimum diameter at tip under bark.	Maximum and minimum diameter 5-ft. from butt under bark.
Ft.	*In.*	*In.*
24	4 to 6	6½ to 8½
26	,,	6½ to 9
30	,,	7 to 9½
34	,,	7½ to 10
40	,,	8 to 10
50	,,	9 to 11
60	,,	10 to 12

ii. "B" size.—Sound, fairly straight and free from large branch knots.

Specification

Length.	Maximum and minimum diameter at tip under bark.	Maximum and minimum diameter at 3-ft. from butt under bark.
Ft.	*In.*	*In.*
15	1½ to 2½	2 to 3½
17	2 to 3	3 to 4½
22	1½ to 2½	2½ to 4
24	2 to 3	3½ to 5

13. **Round timber and brushwood supplies (brush).**—In addition to the supplies described in these instructions, the following should be produced when trees or brushwood are felled :—

Pickets—The principal source of supply is from thickets, but small quantities can also be obtained from the straight boughs of trees.

Manufacture.—Sticks should be straight, stiff and pointed at one end, the other end being sawn square, so that they may be easily driven into the ground.

The sizes which are generally used and of which stocks should be made are :—

Class.	*Metric size.*	*English size.*	*Average diameter.*
Z.S.	1 m.	3 ft. 3 in.	2 in. to 3 in.
Z.H.	1½ m.	4 ft. 11 in.	2½ in. to 3½ in.
Z.L.	1¾ m.	5 ft. 9 in.	3 in. to 4 in.
Z.R.	2 m.	6 ft. 6 ft.	3 in. to 4 in.

Use.—

Z.S. for anchor pickets of apron wiring.

Z.H. for knee wiring—placed in front of apron wiring.

Z.L. for main pickets of apron wires.

Z.R. for revetting.

The pickets chiefly used are 1-metre and $1\frac{3}{4}$-metre, and are used in the proportion of two 1-metre to one $1\frac{3}{4}$-metre.

The $1\frac{1}{2}$ and 2-metre pickets are used in about equal proportions.

Class ZX.—In thickets it is generally found that the wood suitable for Z.S. and Z.H. pickets is in excess of the proportion required. A stock of pieces suitable for Z.S. and Z.H. pickets cut to length but not pointed, may be made, but the stock should not exceed the number of Z.S. and Z.H. pickets made, and must be stacked separately.

14. **Hurdles.—**

Source of supply from selected material in thickets.

Use.—Hurdles are used for revetting.

Large sizes are usually preferred for breastworks.

Manufacture.—All hurdles should be made with six pickets, the diameter of the pickets being $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. Larger pickets should not be used, otherwise the hurdle becomes very heavy. Lighter pickets, however, are too weak.

The pickets should extend at least one ft. below the bottom of the hurdle, and five or six in. above the top.

Pickets should first be driven into the ground at least one ft., being usually spaced, the brushwood being allowed to extend two in. outside the end pickets.

The pickets having been driven one ft. into the ground, the bottom of the brushwood begins on the ground level.

Hurdles should be made of light brushwood entwined in and out of the pickets, the brushwood to be tightly packed, being pressed down by foot at the bottom, and by hand at the top. The ends of all brushwood should be trimmed.

The hurdle should be wired top and bottom, the wires being wound round the picket two or three times, double wire being used. The wires should be twisted up tight by placing a piece of wood between them, and twisting them together.

Wires should also be run between the centre of the hurdle and the top and bottom of the brushwood ; this helps to hold the hurdle together.

The whole secret of hurdle-making is in keeping the wires which hold the pickets together tight, as otherwise the two end pickets break loose from the brushwood, and the hurdle falls to pieces.

Hurdles are handled many times before reaching their destination and a badly wired hurdle becomes useless long before it comes to the end of its journey.

Hurdle-makers should either work singly or in pairs. If in pairs, one man prepares the brushwood, the other man making the hurdle.

The *sizes which are generally used* and of which stock should be made are :—

Class.	*English size.*	*Metric size.*	*Proportion.*
Z.H.S.	1 ft. 9 in. by 6 ft. 6 in.	55 cm. by 2 m.	15 per cent.
Z.H.M.	3 ft. 0 in. by 6 ft. 6 in.	90 cm. by 2 m.	75 ,,
Z.H.L.	4 ft. 0 in. by 6 ft. 6 in.	1 m. 20 cm. by 2m.	10 ,,

C.Es. occasionally require special sizes, but large stocks of these will not be made unless instructions to do so are given.

15. **Fascines.**—

Source of supply—From selected thickets. If pickets have first been manufactured from the thickets, it is best, if the wood is suitable, to make all hurdles possible from the brushwood, and then, where trees are being felled, to wait until this part of the exploitation is finished before working the remainder of the thicket into fascines. Fascines made from brushwood only, without any light poles, are of very little use, whereas fascines made from the tops of trees with the remaining brushwood are suitable for road-making.

If trees are not being felled, the brushwood should be bundled up for revetting material or for dunnage.

Use.—Principally for roads.

Manufacture.—Brushwood with a good porportion of light poles is placed in trestles so as to compress into a bundle 10 ft. long by about 9 in. diameter. The bundle is then choked and wired (double) in seven places, at equal distances, the two end wires being 6 to 8 in. from the ends of the fascine.

These wires must be choked tightly, so that no pressure can loosen them, and any ends pushed into the middle of the fascine.

The *sizes of fascines* should be :—

Class.	*Length.*	*Average diameter.*
Z.F.	10 ft.	9 in. to 10 in.

16. **Brushwood bundles.**—

Source of supply.—From material in thickets and the heads of trees, which is unsatisfactory for the manufacture of fascines, but which is sufficiently straight for bundles.

Use.—Roads, dunnage and foundations on bad ground.

Manufacture.—Similar to fascines, but less care is taken in the selection of material, and the bundles are only wired single in four places.

The *size of bundles* is as follows :—

Class.	*Length.*	*Average diameter.*
Z.B.	8 ft. to 10 ft.	9 in. to 10 in.

The stock of this supply which should be held depends largely on the locality in which the wood is situated.

The supply will only be produced when it has been ascertained that there is likely to be a demand for it.

Frequently the brushwood is issued in G.S. wagon loads, being tightly packed into the wagons.

17. **Continuous revetting bundles.**—

Source of supply.—From thickets.

Use.—For revetting trenches, etc.

Manufacture.—Long, selected sticks suitable for weaving into basket-work, too small for fascines, are made into bundles.

Five 4-ft. pickets are put in each bundle, the bundles being wired tightly in four places for transport. Three bundles should be sufficient to make 20 ft. of continuous revetting 2 ft. high.

The *size of bundles* is as follows :—

Class.	*Length.*	*Average diameter.*
Z.R.B.	10 ft.	9 in.

18. **Poles.**—Specifications of poles are given in para. 11 of these instructions. "U" poles should be cut from 12 ft. to 15 ft. long, as frequently 12-ft. poles are not sufficiently high for camouflage work.

19. **Bayonet sticks and blob sticks.**—

Source of supply.—From thickets.

Straight, clean sticks 5 ft. 2 in. in length about 1 in. diameter at the tip, and 1½ in. at the butt.

APPENDIX XV

LIST OF MACHINERY REQUIRED FOR ENGINEER BASE REPAIR WORKSHOPS

(Referred to in Sec. 172)

Outline list of machinery based on shops of following sizes :—

Machine shop : fitters, tool store, etc.	...	18,000 f.s.
Forge ...	... ...	5,400 ,,
Foundry	... ...	5,400 ,,
Test ...	... ...	3,240 ,,
Saw-mill	... ...	5,400 ,,

These shops may also be required to work as "Production" shops in a small war (Chapter XXX). The work mainly to be catered for however is repairs to R.E. machinery of a field army of six divisions and the line of communication.

It is assumed that each machine is supplied with ample tools, cutters, etc. Small tools and accessories are not included in this list. Each machine to be complete with electric motor.

A. Machine shop

Lathes, 12-in., to give gap of 4-ft. radius	1
Comb. Turret lathes, 8-in.	10
Lathes, instrument repairers	2
Centre lathes, 8-in.	6
Planing machine, 4-ft. stroke, 2 ft. 6 in. by 1 ft. 6 in. ...	1
Shaping machine, 18-in., 2 ft. 6 in. by 1 ft. 6 in. ...	3
Radial drilling m/c, 4-ft. arm	2
Radial drilling m/c, 3 ft. (drilling to 1 in.)	2
Sensitive drilling m/c (drilling to ½ in.)	6
Horizontal universal milling m/c	2
Vertical milling m/c	1
Surface grinding m/c (table 3 ft. by 2 ft., approx.) ...	1
Cylinder boring m/c (cylinders to 7 in.)	1
Combination cylindrical and crankshaft grinding machine	1
Double emery grinding machine (14-in. wheel)	2
Power hack saw	2
Cold band saw	1
Tool room lathe	1
Drill grinders	1
Engraving m/c	1
Universal tool room grinding machine	1

A. Machine shop—*continued*

Double emery wheel for tool room (14-in.)	1
Heat treatment plant for tools and small parts with pyrometers	1
Bevel gear cutting machine	1
Marking off tables—3 ft. by 2 ft.	2
Black and Decker valve trueing sets	4

B. Forge

Power shearing and cropping machine up to 6 in. by 3 in. R.S.J.	1
Hand shearing machines	2
Blacksmiths' hearth—3 ft. 6 in. by 3 ft. 6 in., W.I. ...	15
Blowers and trunking for blacksmiths' hearth sets ...	1
Sheet bending rolls (plain)	1
„ „ „ (corrugated)	1
Electro-pneumatic power hammer, 2-cwt.	1
„ „ „ „ „ 1-cwt.	1
Oxy-acetylene, welding and cutting sets, with 6 pipes ...	1
Electric welding sets for 2 operators, complete	2
Preheating and annealing furnaces with pyrometers ...	1
Case-hardening furnaces, small	2
Bolt and nut making machine to 1 in.	1
Emery grinding wheels (18-in.)	2
Pneumatic riveting and grinding equipment	1

C. Foundry

Tilting brass furnace, 1-cwt.	1
Iron cupola, 1-ton capacity	1
Moulding boxes—set of 48 of sizes	1
Sand-mill	1
Core sand-mill	1
Oil-fired core drying chamber	1
Crucibles—set of 2 doz. of sizes up to 5-cwt.	1
Hand gantry for shop, 2-tons	1
Pneumatic riddlers	2
„ portable grinders	2
„ „ chippers	2
Hose for pneumatic portable chippers—sets	1

D. Saw-mill

1. *If for repairs only. For pattern shop*

Band saw, 2-ft.	1
Wood lathe	1
Guillotine	1
Recessing machine	1
Overhand planer	1

D. Saw-mill—*continued*

2. General.

Circular saw, 36-in.	1
Thicknessing machine, 24-in.	1
Plane cutter grinder	1
Gulletting machine	1
Vertical spindle moulder	1
Mortising machine	1

3. Add if for productive shop.

Power feed circular saws, 48-in.	6
Circular saws, 36-in.	8
Cross cut saws (table or pendulum)	4
Picket sharpening machine	1
Thicknessing machine, 24-in.	2
Gulletting machine for circular saws	1
Tenoning machine	1
General joiner	1
Dust extraction plant for above	1

E. Miscellaneous

Air compressor plant, 200 cf/min/100 lb. sq. in.	1
Standby power plant, 150 K.V.A., A.C., 3 ph., 400 V. ...	1
Screwing machine to 1-in. bolts and 4-in. pipe	1
Coppersmiths' brazing hearths	2
Electric testing sets, 16 kw.	4
Water brake to 250 h.p.	1
Portable paint spraying machines	2
Paint mill	1
Pipe bending machine to 4 in.	1
Self-contained hydraulic press, small	1
Grease removal plant for engine parts	1
Portable cranes—tracked, 5-ton	1
,, ,, ,, 1-ton	1
Runabout trucks	2
Trailers of sorts for runabout trucks	6
Battery charging plant	1
Magneto testing bench with motor drive	1
Electromagnet for remagnetising	1
Testing set, H.V. (3,500 V.)	1
Ames test bench (for small I.C. engines)	1
Weaver press	1

APPENDIX XVI

LIST OF ELECTRICAL STORES REQUIRED FOR A HIGH-VOLTAGE DISTRIBUTION SYSTEM FOR A TYPICAL BASE AREA

(*As illustrated on Pl.* **118**)

This list gives the stores required for main distribution only. The reasons given in Appendix XVII for not including the stores required for the internal distribution of water in depot and other areas apply equally to the low voltage distribution of power and lighting supplies.

Similarly the quantities given below may be varied proportionately to meet the requirements of a base spread over a larger or smaller area than the 50 square miles taken in the typical base illustrated.

The following remarks are made in amplification of Pl. **118** and of the list given below :—

i. The estimate is based upon ten radiating high voltage lines, as indicated on the Plate, the total estimated length being 45 miles.

ii. 0·193-in. diameter H.D. copper conductors are shown in chain-dotted lines ; 0·162-in. diameter conductors in double chain-dotted lines.

iii. The plain dotted lines can be linked up as alternative routes when opportunity offers, but stores for them are not included in the list below.

iv. The 32 and 34-ft. poles are provided for uneven ground and for road crossings. The 36-ft. poles are included for 5 miles of subsidiary camp H.V. lines (not shown on Plate) and will be found useful in cases when H.V. and L.V. lines following the same route can be carried on the same poles.

v. A substation of light construction or steel kiosk (*see* Text Book of Electrical Engineering, 1931, Pls. **39**, **40** and **42**) will be required to house the 3 phase transformers, unless local conditions are suitable for the use of the pole-mounted type.

vi. The lead in from H.V. lines to these buildings should be by cable, and 600 yds. has been allowed for this purpose. An additional 400 yds. has been included for special cases.

vii. For scattered camp lighting, small single phase pole transformers are preferable, installed as indicated on Pl. **41** of the Text Book of Electrical Engineering, 1931.

viii. The normal span between poles is 150 ft., but this may be varied according to local conditions, when the number of poles and other stores must be altered accordingly.

LIST OF STORES

Based on Table T, Military Text Book of Electrical Engineering, 1931

Item	
Poles, 36 ft. long, 11 in. to 11½ in. butt diameters ...	200
,, 34 ft. ,, 9 in. to 9½ in. ,, ,, ...	200
,, 32 ft. ,, 9 in. to 9½ in. ,, ,, ...	200
,, 30 ft. ,, 8½ in. to 9 in. ,, ,, ...	1,400
Insulators, pin type, 6,600 volts, 400 lb.	7,500
Insulator pins for ditto, 400 lb.	6,750
Insulator pole brackets for ditto	6,750
Coach screws, 3½ in. by ½ in., for ditto	21,000
Insulators, tensioning, 6,600 volts, 1,500 lb. complete with straining clamps for fixing to pole	200
Ditto, cross arm	400
Steel channel arms, 4 in. by 2 in. by 4 ft. long for ditto	200
Bolts, G.I., 8 in. by ⅝ in. for ditto	200
Wire, copper, hard drawn, 0·193 in. diameter (5,400 yds., 1,840 lb. per mile run)	36,000 lb.
Ditto, 0·162 in. diameter (5,400 yds., 1,300 lb. per mile run	39,000 ,,
Wire, copper annealed, 14 S.W.G.	1,100 ,,
Wire, stay, G.I. 7 strands/0·16 in. diameter, yards 80 ...	10,000 ,,
Staples, G.I. No. 4 S.W.G.	250 ,,
Rods, stay, G.I., 8 ft. long, ¾ in. diameter	400 ,,
Blocks, stay (creosoted timber, 8 in. by 4-in. by 4 ft. long)	400
Cable, 3 core, 6,600 volts, paper insulated, lead covered and armoured, 0·0225 square in.	1,000 yds.
Cable terminating boxes for above—	
Indoor wall mounting type	40
Outdoor pole mounting type	40
Transformers complete with suitable control gear, 3-phase, 50 cycles, 6,600/407/235 volts, Delta Star, oil-cooled **indoor* type, with 2½ per cent. and 5 per cent. tappings	
200 K.V.A.	4
100 K.V.A.	10
50 K.V.A.	10
25 K.V.A.	15
Ditto, single-phase, 50 cycles, 6,600/235 volts, oil-cooled, *pole mounting type*, with 2½ per cent. and 5 per cent. tappings	
10 K.V.A.	25
5 K.V.A.	15
Danger notices	2,000
Number plates	2,000
Barbed wire, 14 S.W.G.	2,000 lb.

* Where local conditions are suitable outdoor pole mounted transformers can be supplied in all these sizes.

APPENDIX XVII

LIST OF WATER SUPPLY STORES REQUIRED FOR THE MAIN DISTRIBUTION SYSTEM FOR A TYPICAL BASE AREA AS ILLUSTRATED ON PL. 120

This list gives stores required for main distribution only. Those required for internal distribution in the various depots, etc., are entirely dependent on the geographical conditions governing the lay-out of the depots and no reliable indication of the quantities required would be furnished by calculations made on a purely hypothetical lay-out.

This is not the case with a main distribution system, as extremes are likely to cancel out, and the net result can be taken to be a reasonably accurate forecast of the quantities required for a lay-out of a base spread over a particular extent of ground, in the case under consideration an area of some 50 square miles.

If in actual practice the base were to extend over a smaller or larger area, these quantities could be varied proportionately.

The only item which may cause a large variation is the position of the main pumping station, which obviously must depend on the source of supply. If this is a river, it must be above the brackish water line. In the case under consideration, a reasonable assumption has been made, viz. an intake 8 miles from the mouth of the river.

The actual distribution system illustrated is one of many possible alternatives, and is based on the following considerations :—

i. The base has been assumed to be reasonably level.

ii. No pipes larger than 6 in. have been used, and the bulk of the supply is in that sized pipe.

iii. The maximum pressure in the 6-in. main does not exceed 210 lb. per sq. in., which is well within permissible limits, and that only in the first section from the main pumping station.

iv. To reduce friction losses due to the heavy flow in the two main sections of the system, the 6-in. pipes have been duplicated and are cross connected at frequent intervals. Under active service conditions this is considered more satisfactory than the employment of larger pipes.

v. Two intermediate pumping stations with break pressure tanks are also introduced into the system. Storage at these points has been taken up for on the basis of a two hour pumping capacity at each.

vi. The distribution is on the ring main system, and the capacities of the various branches are such that the general supply should be unaffected by a cut in any one branch.

vii. Storage is taken up for on the basis of one day's supply at each depot, etc.

viii. No stores required at the main pumping station are included, as these depend entirely on the source of supply and the amount of settlement and purification which may be necessary in any particular case.

LIST OF STORES

Based on Military Engineering, Vol. VI

Piping.	6-in.	4-in.
Length	41 miles	3 miles
Fittings.		
¼ bends	200	20
⅛ bends	200	20
1/16 bends	200	20
Elbows	200	20
Tees, equal	300	20
,, reducing to 4-in.	40	—
,, ,, 2-in.	—	40
Sockets	300	50
,, diminishing to 2-in.	—	—
Connectors, long	500	40
,, short	500	40
Cross pieces	150	10
Plugs	150	10
Caps	150	10
Nipples	400	40
Back nuts	600	50
Screwed flanges	250	20
45° branches (right and left)	200	10
Sluice valves	100	10
Air valves	100	10
Reflux valves	100	10
Notice boards	100	20

List of stores—*continued*

Storage Tanks

Pressed steel tanks in 20,000-gal. units	60 units or a total storage of 1,200,000 gals.
Standard steel staging for above in 10 ft. units.	240 units.

Pumps

Main pumping station	2 pumps each capable of pumping 50,000 gals. an hour against a 500 foot head, *i.e.* approximately 200 h.p. each.
Subsidiary pumping stations	8 pumps each capable of pumping 20,000 gals. an hour against a 250 foot head, *i.e.* approximately 40 h.p. each.

With necessary spares, pumphouse equipment, etc.

Whether these pumps will be driven electrically or otherwise will depend on whether the base is being equipped with central power station and h.v. transmission or not.

APPENDIX XVIII

EXAMPLES OF ROPEWAYS FROM ACTUAL PRACTICE

(*Referred to in Sec.* **200**)

A. General utility ropeway designed for the War Department in 1918

The whole plant was standardized, with a large measure of interchangeability of parts.

Capacity: 30 tons an hour in 5-cwt. loads at 60 yds. interval. If required, 10-cwt. loads could be run on two carriers, with the interval increased to 150 yds.

Average trestle spacing, 110 yds.; maximum spans, 330 yds.; self-aligning sheaves allowed of rough erection.

The rope (Lang's lay, $2\frac{5}{8}$ in. circumference, 22 tons breaking strain, and working tension 4 tons) was driven at 360 ft. a minute by 30 b.h.p. petrol or oil engines.

The lengths of section with 15 tons an hour capacity which could be worked with 30 b.h.p. are :—

Grade	*Loads*	*Length*
Level	Full both sides	3·8 miles.
Level	Full up. Empty down	5·0 ,,
5 per cent.	,, ,,	2·5 ,,
10 per cent.	,, ,,	1·65 ,,
20 per cent.	,, ,,	1·0 ,,

All running at 120 yds. a minute.

The supports are lattice steel standards and these are erected in 6-ft. lengths. The average distance between the trestle standards supporting the cable is 110 yds.; but the maximum span which can be arranged is 830 yds.

B. Ropeway conveying ore from Messrs. Baird's mines at Santander

(Erected by Ropeways Limited)

Capacity: 60 tons an hour. The output of the mines is 500 tons a day.

Length: 6,125 yds.

Difference in level: 374 ft. in favour of the load.

Speed of rope: 410 ft. a minute.

Capacity of buckets: 10 cwt.

Number per hour: 120.

Spacing between buckets: 205 ft.

Power required to operate the line: about 18 b.h.p. (the motor installed was of 30 b.h.p. to overcome the initial inertia in starting the ropeway, and to allow for contingencies, such as stiff bearings, during cold weather and snow).

Rope: $3\frac{3}{8}$ in. in circumference and working with a minimum factor of safety of 5, including cumulative tension and friction pulls.

Number of trestles: 50; maximum height: 40 ft.

C. Self-acting ropeway for Millar's Timber and Trading Co. at Salonika

(Erected by Ropeways Limited)

Capacity: 20 tons an hour of sawn timber from forest mill to railway.

Length: 12,795 yds.

Difference in level: 3,232 ft. in favour of the load.

Speed of rope: 394 ft. a minute.

Weight of nett loads: 4 to 5 cwt. (with occasional heavier ones on two carriers).

Number per hour: 67 to 80.

Spacing between loads: 354 ft. or 295 ft. (for double carriers).

Surplus power developed: 36 b.h.p., absorbed by regulating fans (*see* below).

Rope: $2\frac{3}{4}$ in. circumference plough steel, working with a minimum factor of safety of $4\frac{1}{2}$.

Number of trestles: 75, the tallest of which is 70 ft., but apart from three others of over 50 ft. in height, the average height is not more than 25 ft. The ground traversed, though irregular and hilly, is free from unduly long spans or other circumstances which would necessitate tall trestling.

To site the mill at the foot of the ropeway would have involved sawing all the logs to reasonable sizes, *i.e.* no piece to weigh more than $\frac{1}{2}$ ton; it was, therefore, sited at the upper end of the ropeway and the line was used for the conveyance of the sawn timber instead of logs, at an appreciably reduced cost.

On account of its length, the line was divided at a point which would give approximately the same tensional pulls on each section; the upper section is, therefore, 5,100 yds. in length with a fall of 1,910 ft., whilst the lower section is about 7,695 yds. in length with a fall of 1,322 ft. approximately.

At the intermediate station, the ropes from both sections run round a double-grooved wheel, to which is also fixed a heavy toothed ring and gearing from which regulating fans are driven. These fans are enclosed in an iron casing, fitted

with a shutter or door. By opening the door a greater draught is allowed to come through the fan, which increases in resistance, so that by suitable adjustment of the shutter the ropeway can be kept to any desired speed within reasonable limits above or below the normal. Apart from the regulating fans, a brake band is also fitted to these double grooved wheels, by means of which the ropeway is stopped or started as required.

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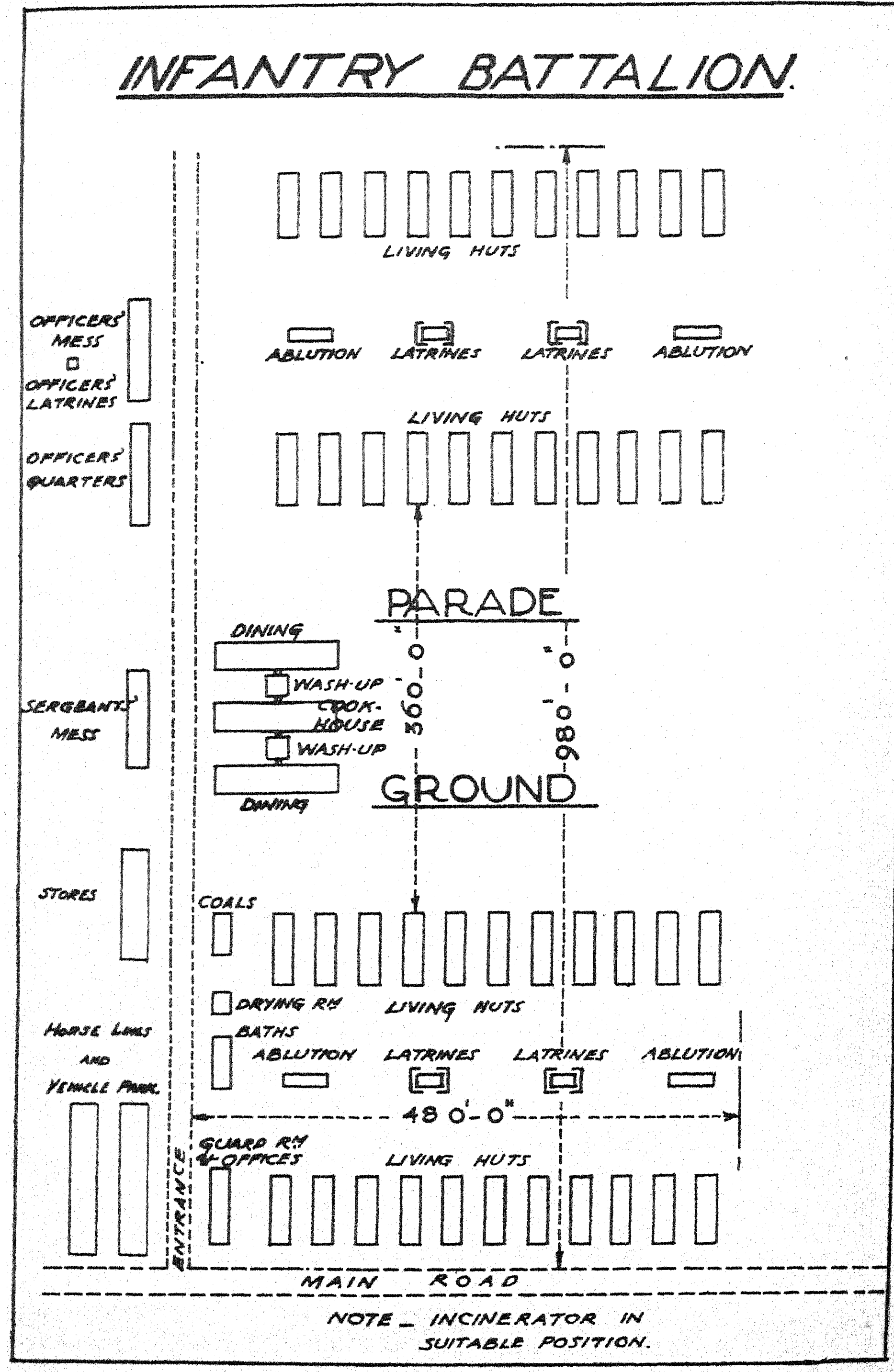
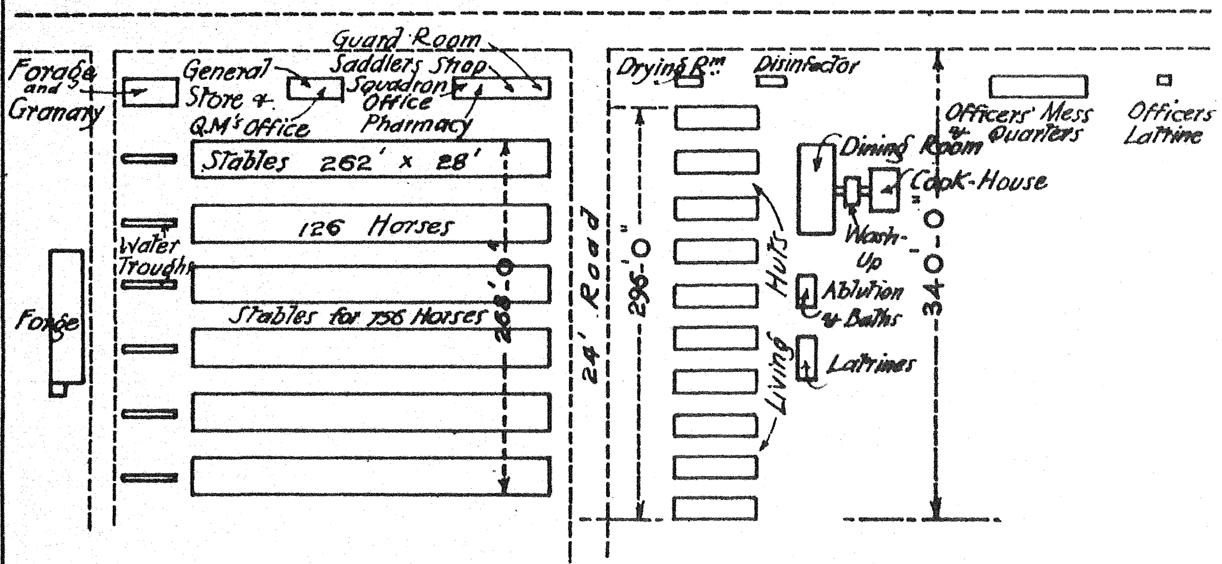

INFANTRY BATTALION.
LIVING HUTS
ABLUTION
LATRINES
LATRINES
ABLUTION
OFFICERS' MESS
OFFICERS' LATRINES
LIVING HUTS
OFFICERS' QUARTERS
PARADE
GROUND
DINING
WASH-UP
COOK-HOUSE
WASH-UP
DINING
360'-0"
980'-0"
SERGEANTS' MESS
STORES
COALS
DRYING RM
LIVING HUTS
BATHS
HORSE LINES AND VEHICLE PARK.
ABLUTION
LATRINES
LATRINES
ABLUTION
480'-0"
GUARD RM & OFFICES
LIVING HUTS
ENTRANCE
MAIN ROAD
NOTE _ INCINERATOR IN SUITABLE POSITION.

PLATE

BASE REMOUNT DEPOT:

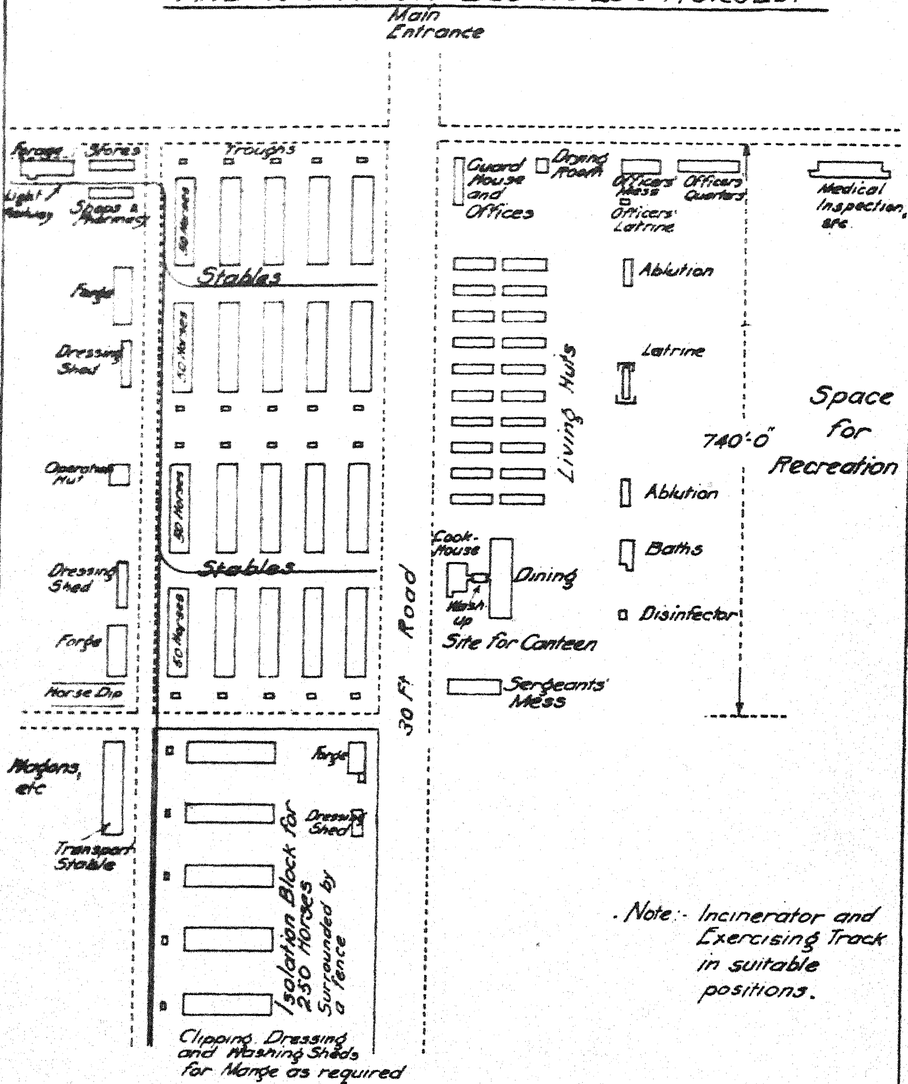
FOR 1 SQUADRON = 750 HORSES.



Note:- Incinerator, Exercising Track, Railway Siding and Horse Dip (if provided) in suitable positions

VETERINARY HOSPITAL.

1,000 HORSES AND ISOLATION BLOCK 250 HORSES.



Note:- Incinerator and Exercising Track in suitable positions.

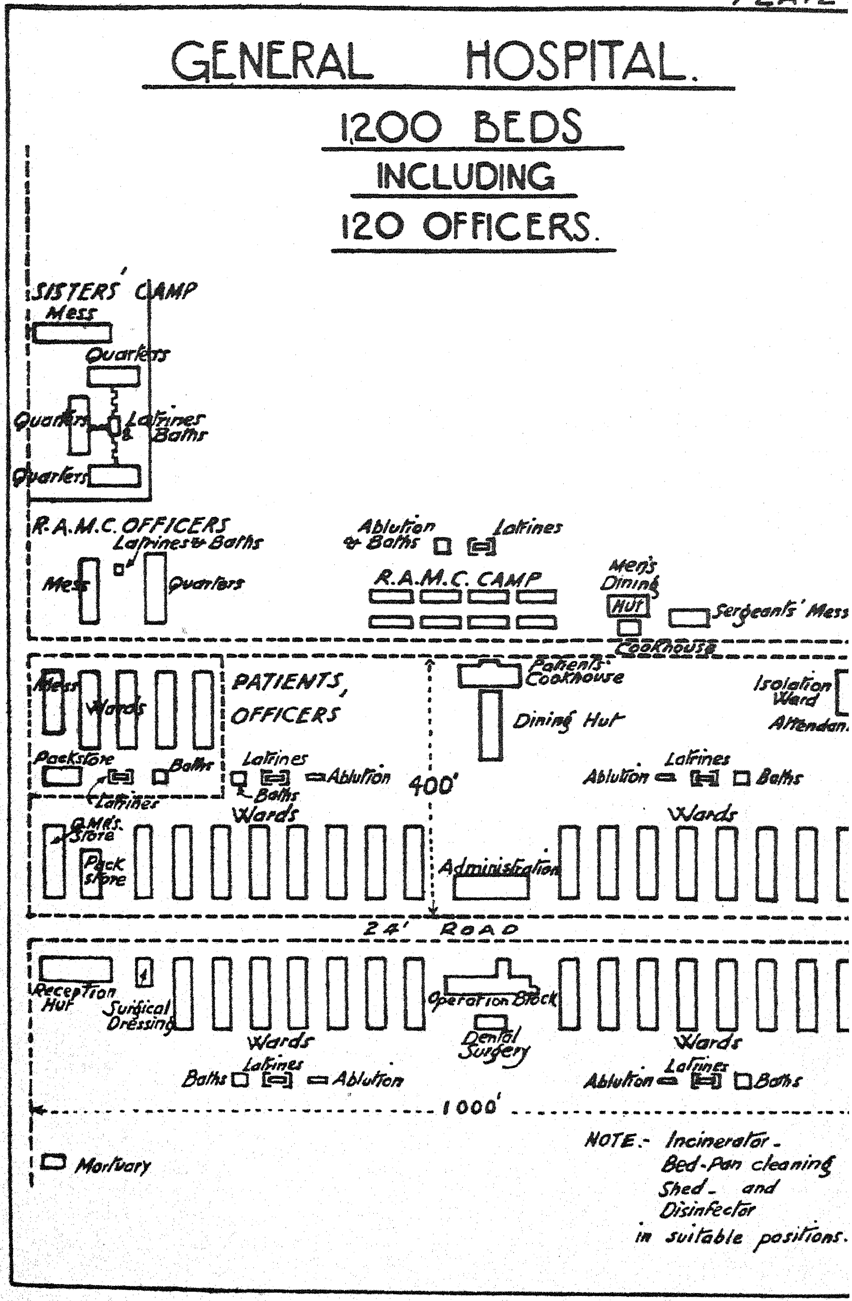
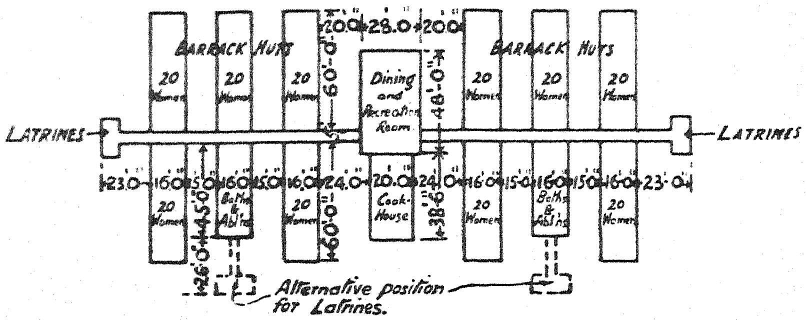

GENERAL HOSPITAL.
1200 BEDS
INCLUDING
120 OFFICERS.
SISTERS' CAMP
Mess
Quarters
Quarters
Latrines & Baths
Quarters
R.A.M.C. OFFICERS
Latrines & Baths
Mess
Quarters
Ablution & Baths
Latrines
R.A.M.C. CAMP
Men's Dining HUT
Sergeants' Mess
Cookhouse
Patients' Cookhouse
Mess
Wards
PATIENTS, OFFICERS
Isolation Ward
Attendan.
Dining Hut
Packstore
Latrines
Baths
Latrines
Ablution
Baths
400'
Latrines
Ablution
Baths
Wards
Wards
Q.M.'s Store
Pack store
Administration
24' ROAD
Reception Hut
Surgical Dressing
Operation Block
Dental Surgery
Wards
Wards
Latrines
Baths
Ablution
Ablution
Latrines
Baths
1000'
Mortuary
NOTE.- Incinerator - Bed-Pan cleaning Shed - and Disinfector in suitable positions.

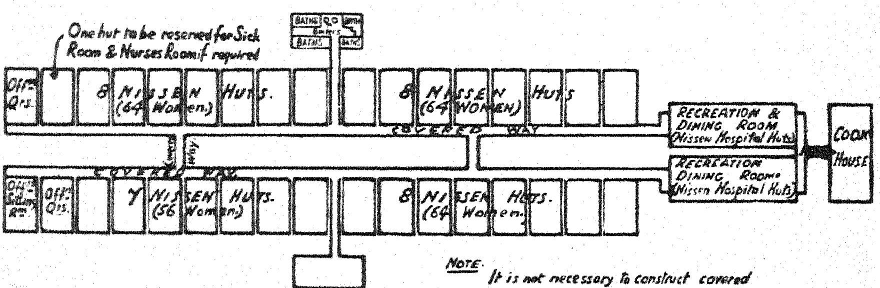
PLATE 5

WOMEN'S CAMPS.

TWO TYPICAL LAY-OUTS.



LAY-OUT TO ACCOMMODATE 200 WOMEN.
(OFFICERS' QUARTERS SEPARATE.)

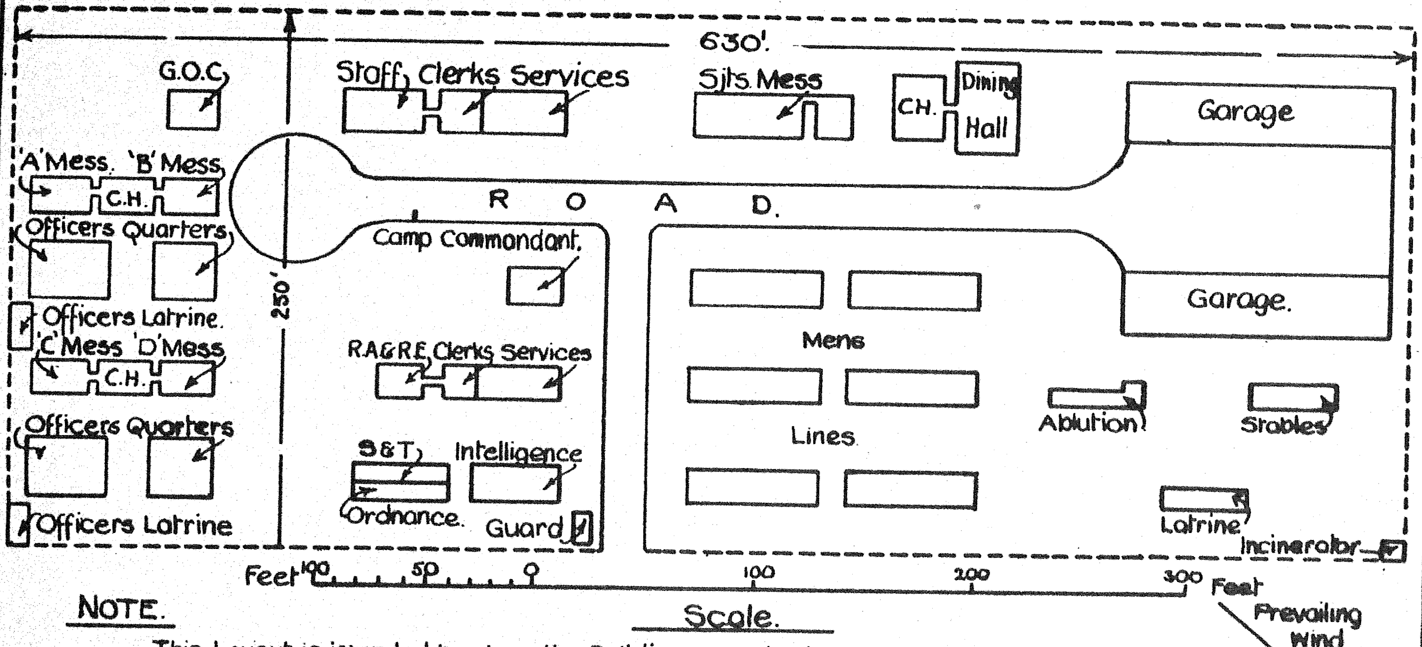


NOTE. It is not necessary to construct covered ways in the first instance, but lay-out should be so arranged that they can be added if necessary.

LAY-OUT USING NISSEN HUTS, TO ACCOMMODATE 8 OFFICERS & 248 WOMEN.

Plate 6.

LAYOUT FOR CORPS HEADQUARTERS.



NOTE.

This Layout is intended to show the Buildings required at a Corps H.Q., and how each should be appropriated. All camps should be laid out to suit the ground and as far as possible concealed from the air.

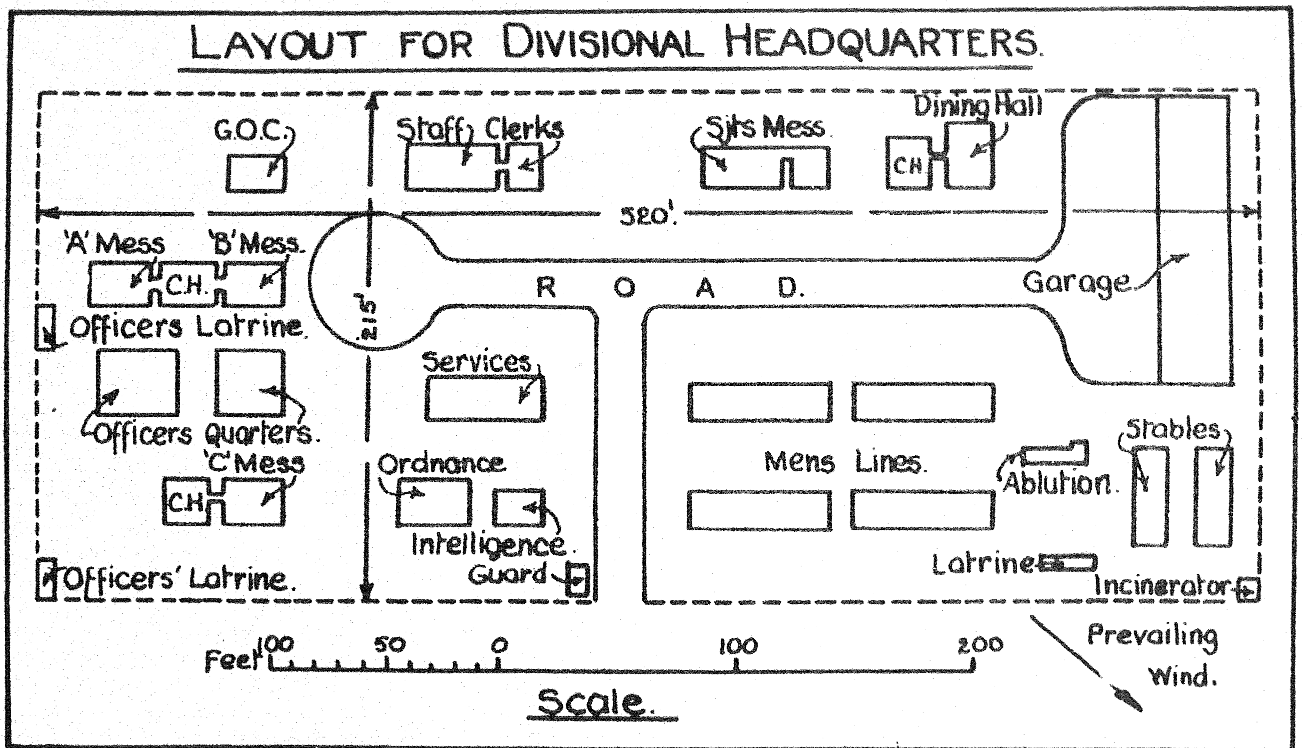

LAYOUT FOR DIVISIONAL HEADQUARTERS.
G.O.C.
Staff Clerks
Sjts Mess.
Dining Hall
CH
520'.
'A' Mess
'B' Mess.
C.H.
Officers Latrine.
R O A D.
Garage
Services
Officers Quarters.
'C' Mess
C.H
Ordnance
Intelligence.
Guard
Officers' Latrine.
Mens Lines.
Ablution.
Stables
Latrine
Incinerator
Feet 100
50
0
100
200
Scale.
Prevailing Wind.

Plate 7.

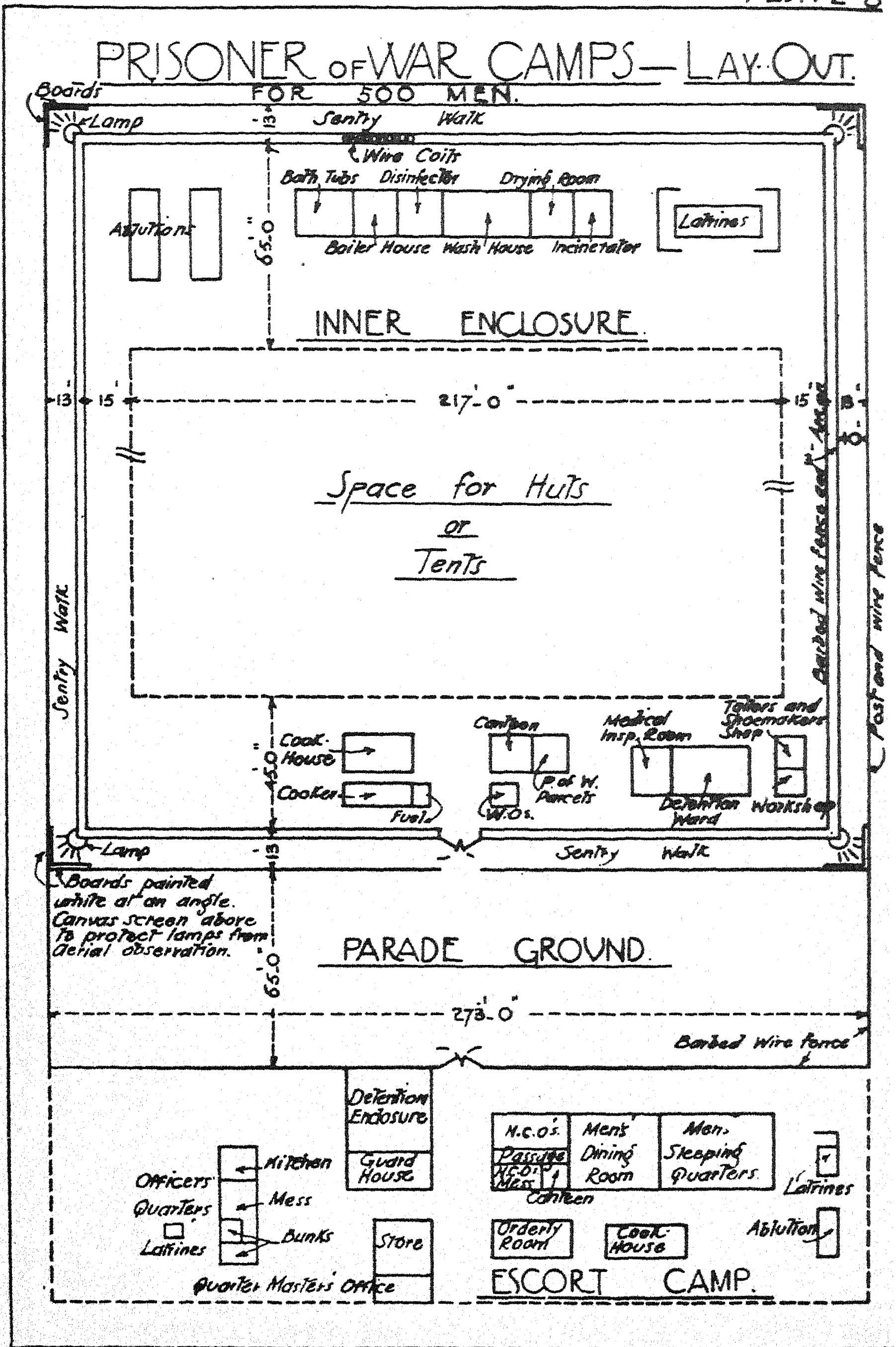

PRISONER OF WAR CAMPS — LAY-OUT.
FOR 500 MEN.
Boards
Lamp
13'
Sentry Walk
Wire Coils
Bath Tubs
Disinfector
Drying Room
Ablutions
65'0"
Latrines
Boiler House
Wash House
Incinerator
INNER ENCLOSURE.
13'
15'
217'0"
15'
13'
10'
Space for Huts
or
Tents
Sentry Walk
Barbed wire fence
Post and wire fence
Cook-House
45'0"
Cooker
Fuel
Canteen
P. of W. Parcels
W.Cs.
Medical Insp. Room
Tailors and Shoemakers Shop
Detention Ward
Workshop
Lamp
13'
Sentry Walk
Boards painted white at an angle. Canvas screen above to protect lamps from aerial observation.
PARADE GROUND.
65'0"
273'0"
Barbed Wire Fence
Detention Enclosure
Guard House
N.C.O.s.
Passage
N.C.O.s Mess
Canteen
Men's Dining Room
Men's Sleeping Quarters.
Latrines
Officers' Quarters
Kitchen
Mess
Bunks
Latrines
Store
Quarter Masters' Office
Orderly Room
Cook-House
Ablution
ESCORT CAMP.

PLATE 9.

MILITARY PRISON
FOR 300 MEN

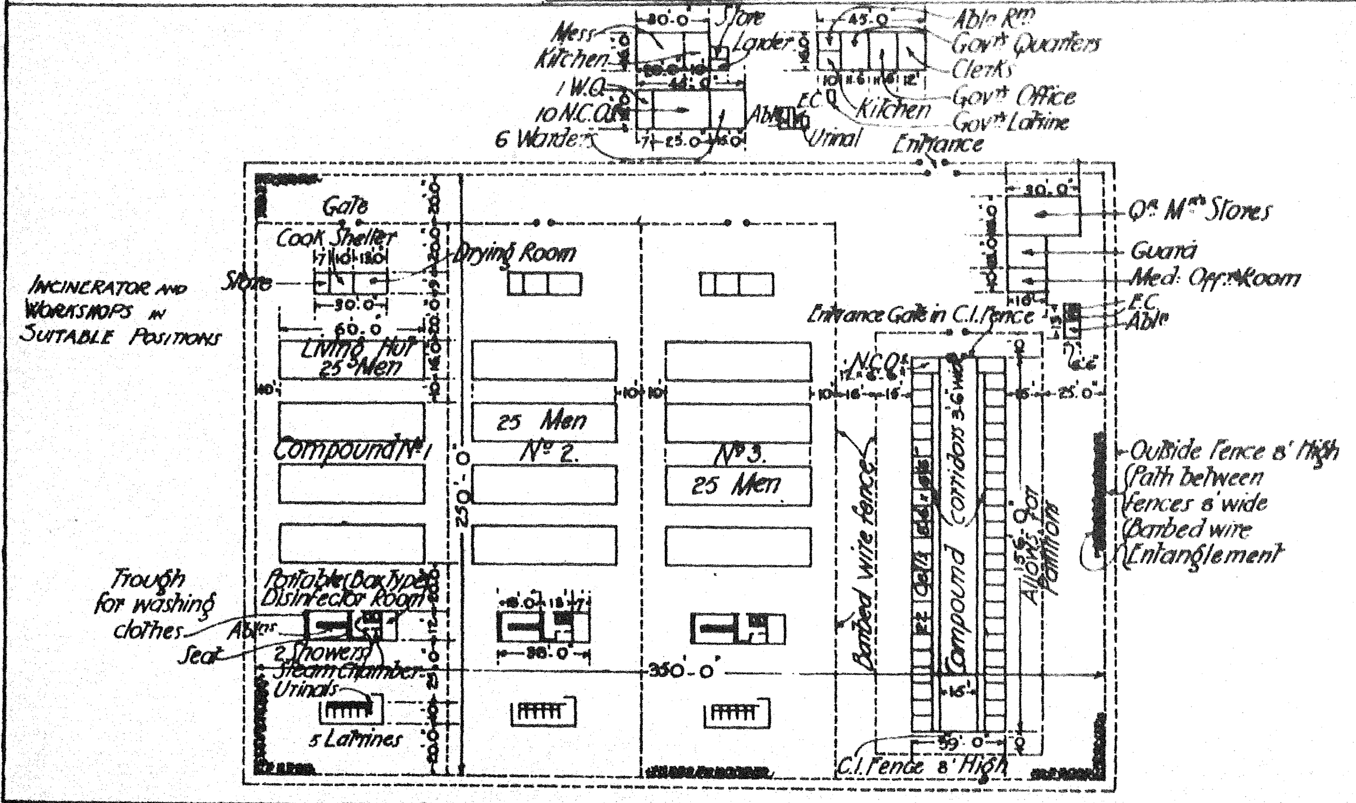


Plate 10.

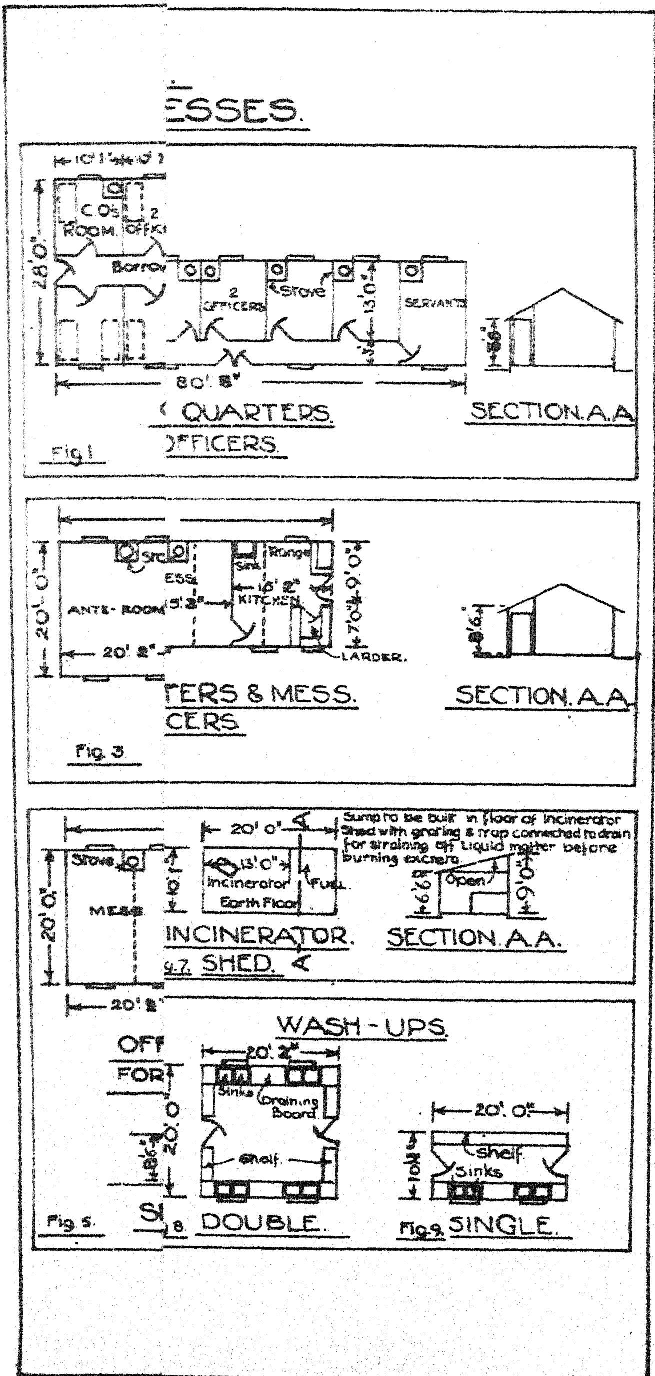
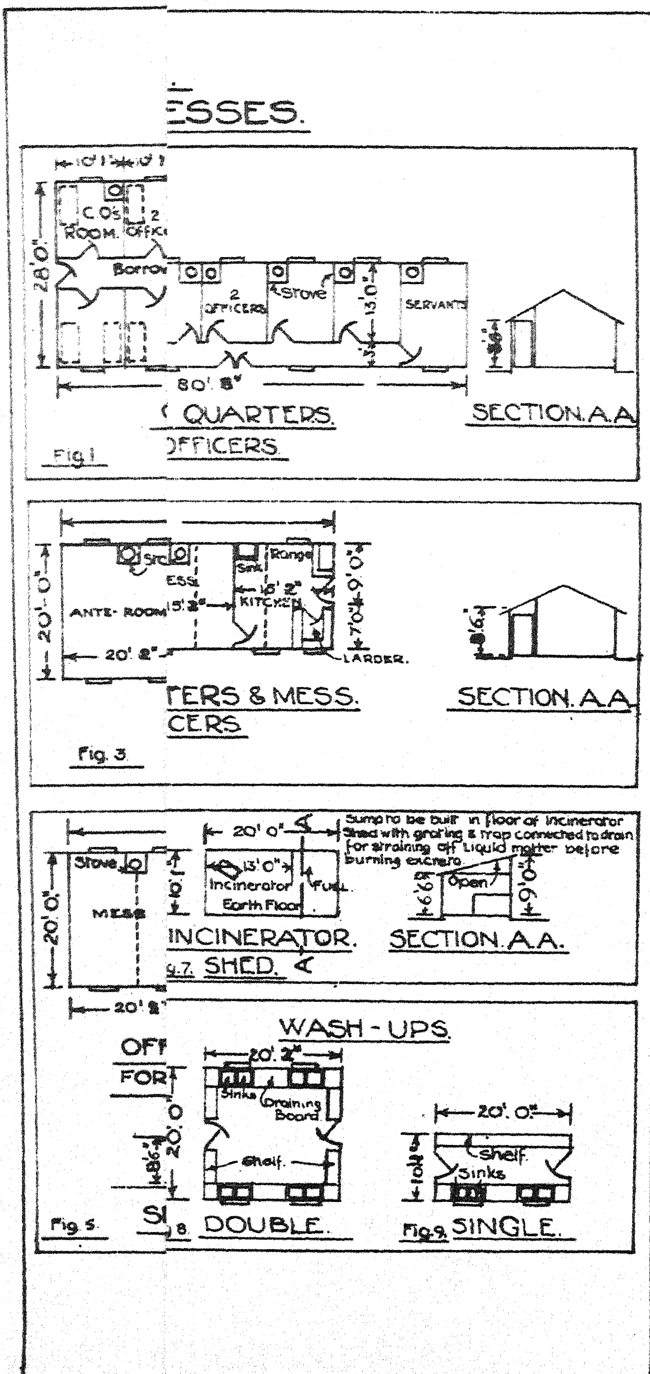
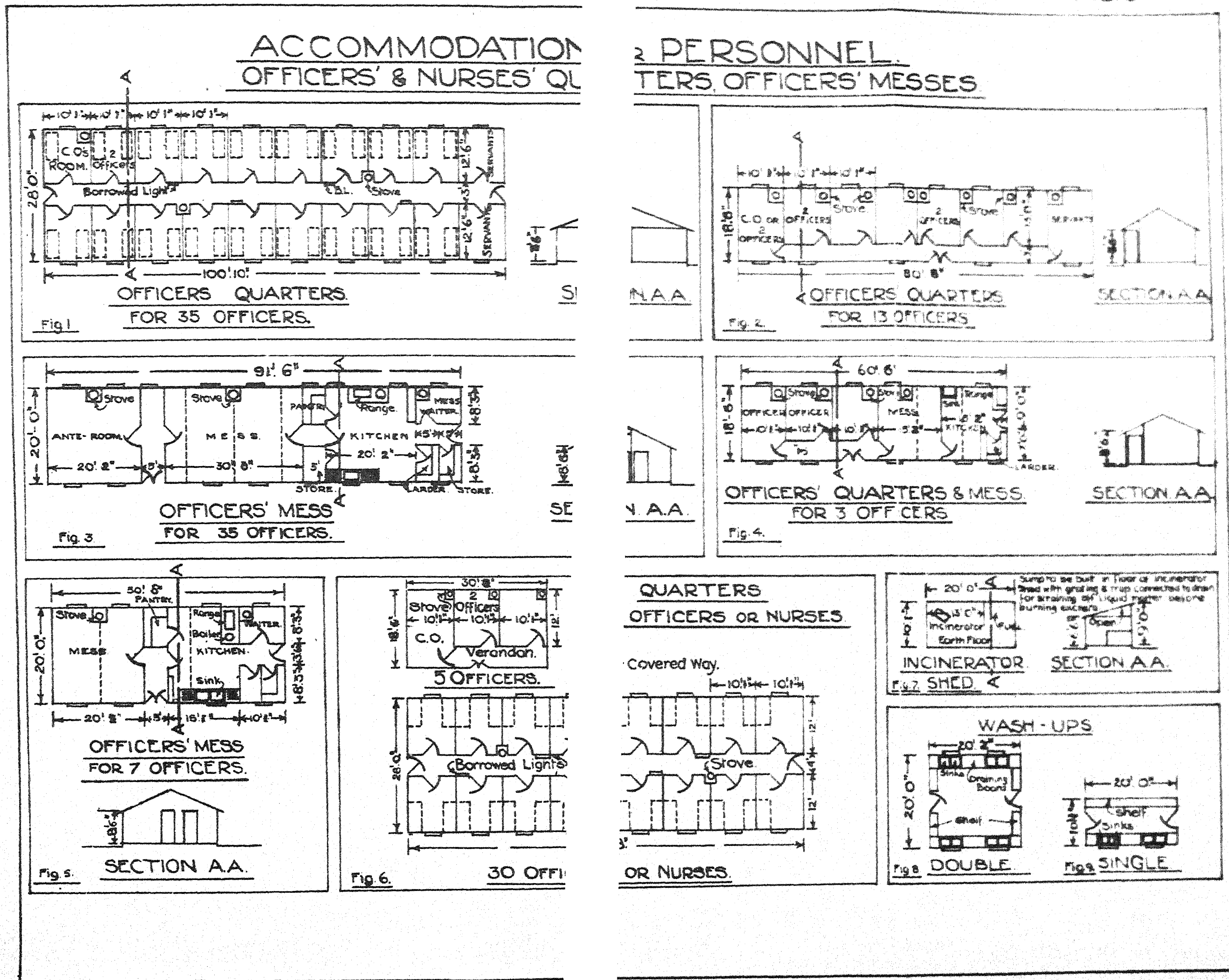

ESSES.
C.O's ROOM.
2 OFFIC
Borrow
2 OFFICERS
Stove
SERVANTS
28'0"
13'0"
80'. 8"
QUARTERS.
OFFICERS.
SECTION. A.A.
Fig 1
Stove
ESS
ANTE-ROOM
15'2"
Sink
Range
16'2"
KITCHEN
LARDER.
20'-0"
20' 2"
9'0"
7'0"
TERS & MESS.
CERS
SECTION. A.A.
Fig. 3
Sump to be built in floor of incinerator Shed with grating & trap connected to drain for straining off liquid matter before burning excreta.
20' 0"
13'0"
Incinerator
Earth Floor
Fuel.
Open
Stove
MESS
20'0"
20' 2"
INCINERATOR.
SHED.
SECTION. A.A.
WASH - UPS.
OFF
FOR
20'. 2"
Sinks
Draining Board
Shelf.
20'. 0"
20'. 0"
Shelf.
Sinks
Fig. 5.
DOUBLE.
Fig.9. SINGLE.

Plate 10.



ESSES.
C.O's ROOM.
2 OFFIC
Borrow
2 OFFICERS
Stove
SERVANTS
28' 0"
13' 0"
80' 8"
QUARTERS.
OFFICERS
SECTION. A.A.
Fig. 1
ANTE-ROOM
ESS
Sink
Range
15' 2"
KITCHEN
20' 2"
20' 0"
9' 0"
7' 0"
LARDER.
TERS & MESS.
CERS
SECTION. A.A.
Fig. 3
Stove
MESS
20' 0"
20' 2"
20' 0"
13' 0"
Incinerator
Earth Floor
Fuel
Sump to be built in floor of incinerator Shed with grating & trap connected to drain for straining off liquid matter before burning excreta.
Open
6' 6"
9' 0"
INCINERATOR.
SHED.
SECTION. A.A.
WASH - UPS.
20' 2"
Sinks
Draining Board
Shelf.
20' 0"
20' 0"
Shelf.
Sinks
OFF
FOR
Fig. 5
DOUBLE.
Fig. 9. SINGLE.

Plate 10.


ACCOMMODATION PERSONNEL.
OFFICERS' & NURSES' QU TERS, OFFICERS' MESSES
C.O's ROOM.
2 Officers
Borrowed Light
Stove
SERVANTS
28'0"
100' 10"
OFFICERS QUARTERS.
FOR 35 OFFICERS.
Fig. 1
C.O. OR 2 OFFICERS
2 OFFICERS
80' 8"
OFFICERS QUARTERS
FOR 13 OFFICERS
SECTION A.A.
Fig. 2.
91' 6"
ANTE-ROOM
MESS
PANTRY
Range
KITCHEN
MESS WAITER
20' 2"
30' 8"
STORE
LARDER
OFFICERS' MESS
FOR 35 OFFICERS.
Fig. 3
60' 6"
OFFICER
MESS
KITCHEN
LARDER
OFFICERS' QUARTERS & MESS.
FOR 3 OFFICERS
SECTION A.A.
Fig. 4.
50' 8"
PANTRY
Boiler
WAITER
Sink
OFFICERS' MESS
FOR 7 OFFICERS.
SECTION A.A.
Fig. 5.
30' 8"
C.O.
Verandah.
5 OFFICERS.
Borrowed Lights
30 OFFI
Fig. 6.
QUARTERS
OFFICERS OR NURSES.
Covered Way.
Stove.
OR NURSES.
Incinerator
Earth Floor
Open
INCINERATOR.
SECTION A.A.
Fig. 7. SHED.
WASH-UPS
Sinks
Draining Board
Shelf
20' 0"
DOUBLE.
Fig. 8
SINGLE.
Fig. 9

SERJEANTS' MESSES.

Swing windows in gable ends. Eaves height 8'-0". P.C.C. Floor for kitchen. Kitchen & Liquor Store windows fitted with fixed frames covered with galv. wire gauze.

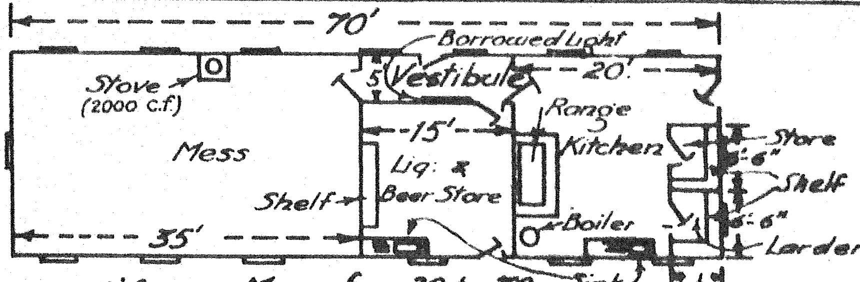


Fig. 1 —Mess for 20 to 30—

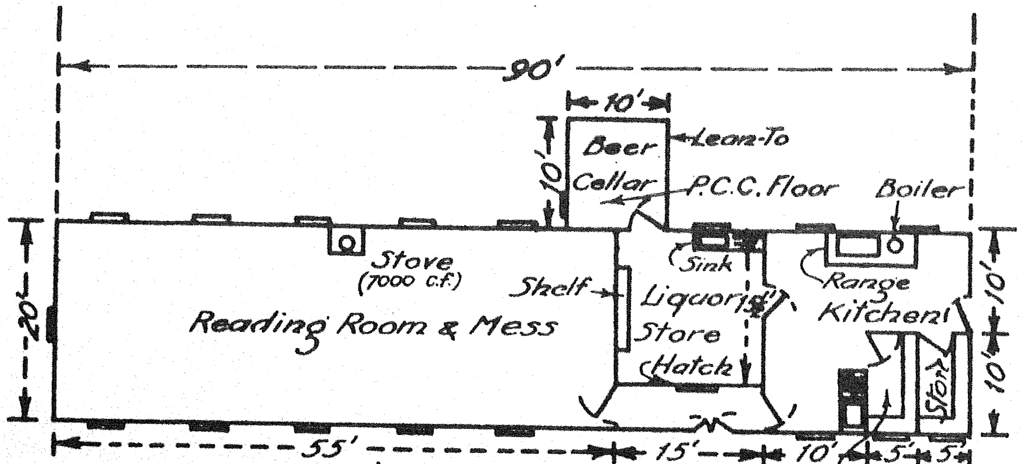
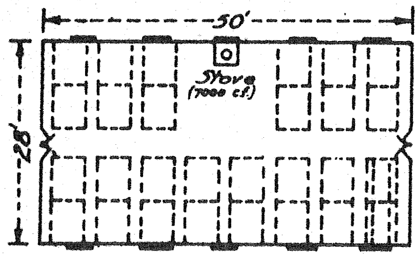


Fig. 2 —Mess for 45 to 50—

DINING HUTS.

Swing windows in gable ends.
Windows covered with wire gauze.

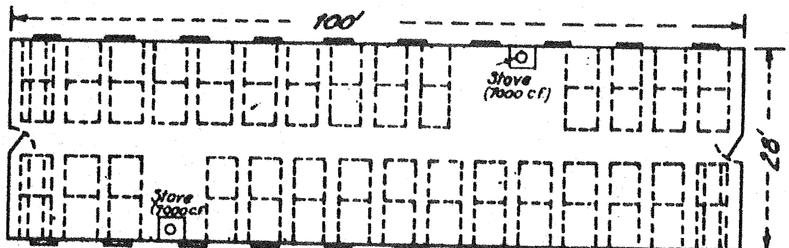


Spacing for group of 2 tables & 4 forms 6' long, soldiers; to seat 16 men. 6' run of wall space per group.

Eaves height 9'-0"

– For 224 men –

— Fig. 1. —

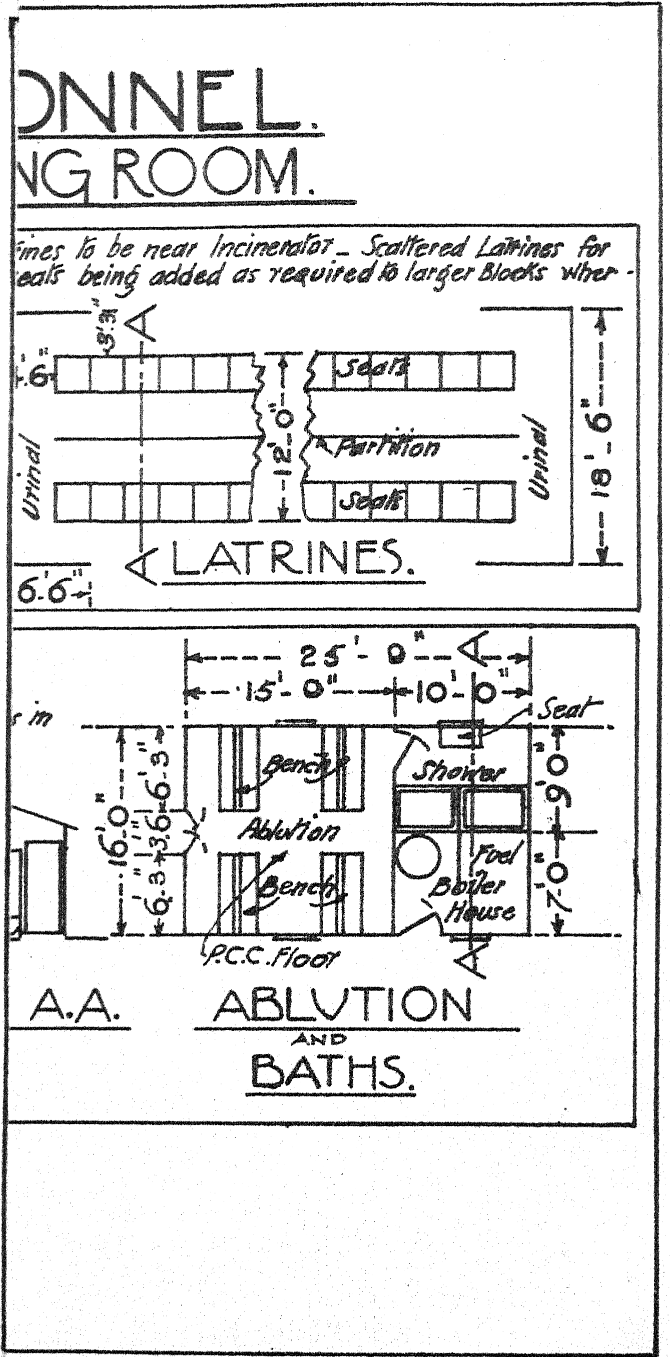


Eaves height 9'-0"

– For 464 men –

— Fig. 2. —

PLATE 13.



ONNEL.
NG ROOM.
ines to be near Incinerator _ Scattered Latrines for
eats being added as required to larger Blocks wher -
Seats
Partition
Seats
Urinal
Urinal
12'-0"
18'-6"
3'-3"
6'-6"
LATRINES.
25'-0"
15'-0"
10'-0"
Seat
Shower
Bench
Ablution
Bench
Fuel
Boiler
House
16'-0"
6'-3"
3'-6"
6'-3"
9'-0"
7'-0"
P.C.C. Floor
A.A.
ABLUTION
AND
BATHS.

TYPES OF COOKHOUSES.

P.C.C. Floors. Swing windows in gable ends. All windows fitted with fixed frames and covered with galv^d wire gauze.

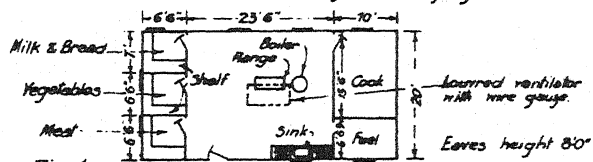


Fig. 1.

For 50 to 100 Hospital Patients.

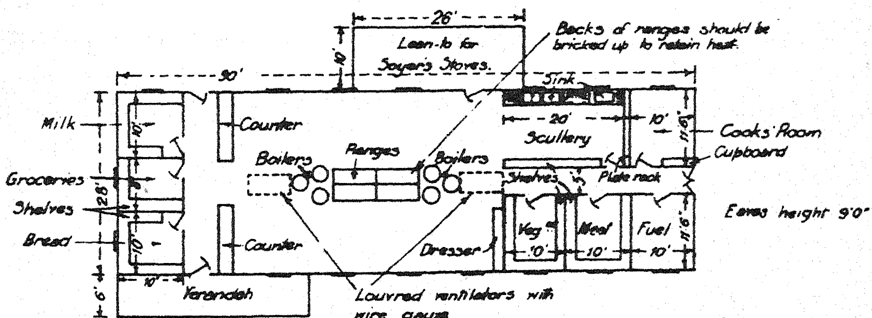


Fig. 2.

For 500 to 1000 Hospital Patients.

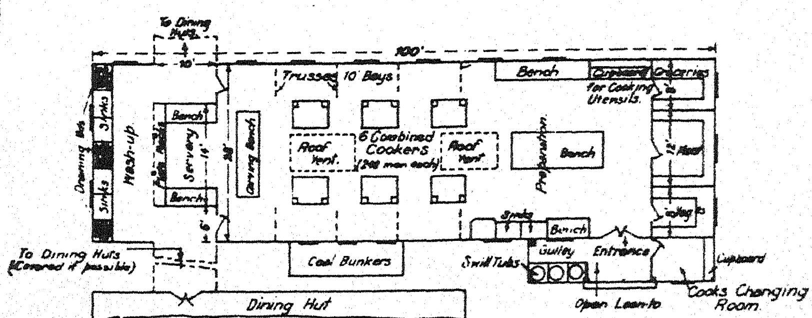
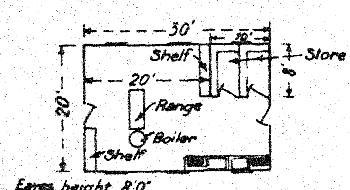


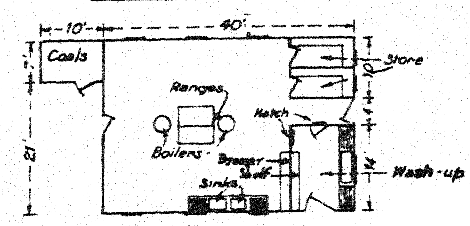
Fig. 3.

For 1500 Men.



For 120 Men

Fig. 5.

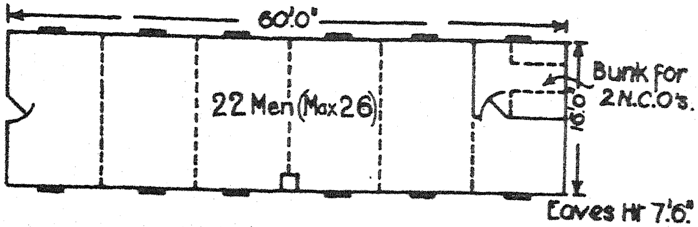


For 360 Men

Fig. 4.

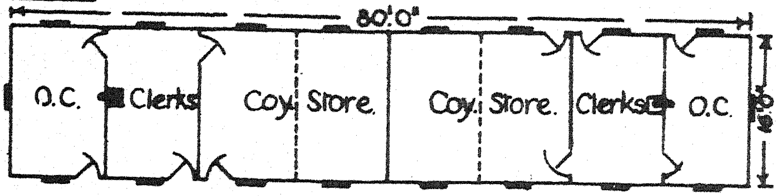
LIVING HUT, OFFICES & STORES.

FIG. 1.



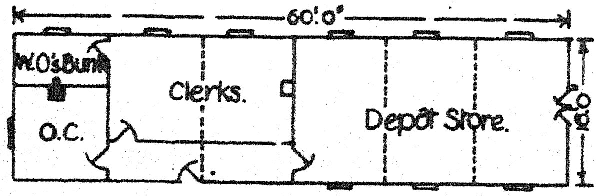
MENS' LIVING HUT.

FIG. 2



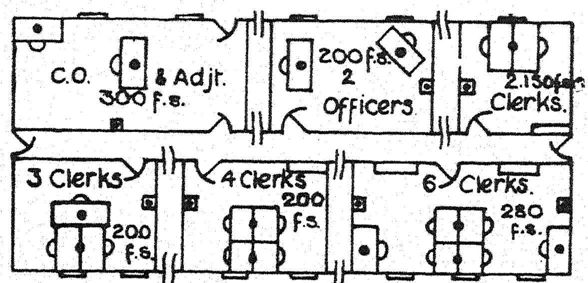
COY. OFFICES & STORES FOR A BATTN

FIG. 3.



DEPOT OFFICES & STORES.

FIG. 4.



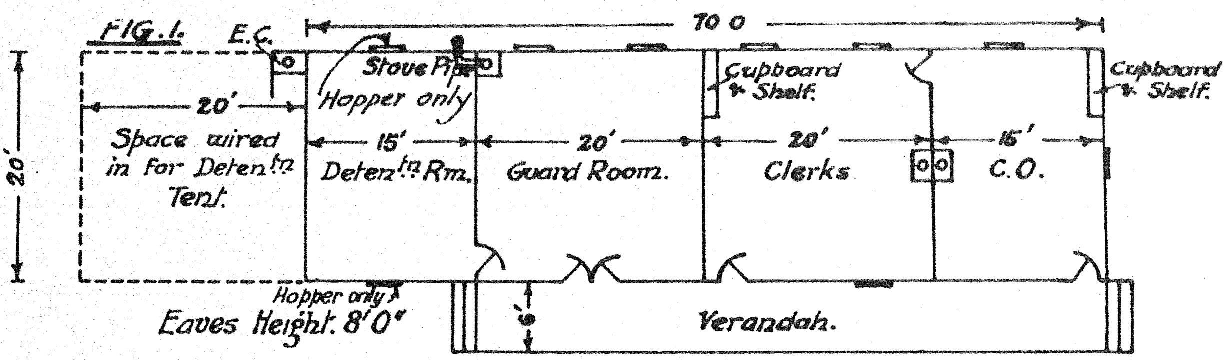
ADMINISTRATIVE OFFICES.

Shewing typical arrangement of tables and electric lights.

GUARD ROOMS & OFFICES.

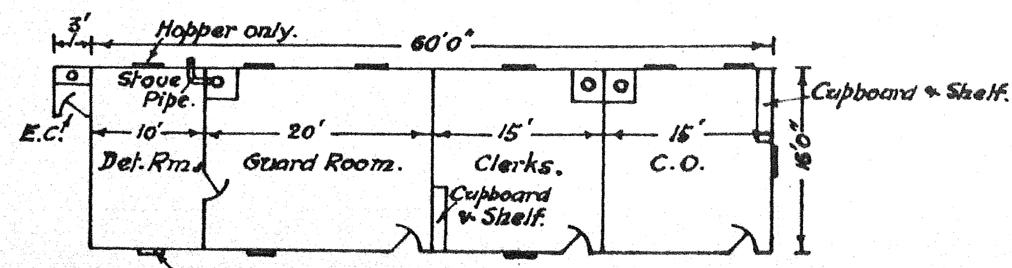
SUITABLE FOR REINFORCEMENT CAMP OR DEPOT OF 1000 MEN.

FIG. 1.



Eaves Height. 8'0"

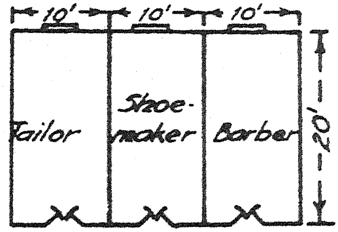
FIG. 2. SUITABLE FOR ONE BATTALION.



Eaves Height. 7'6"

PLATE 17.

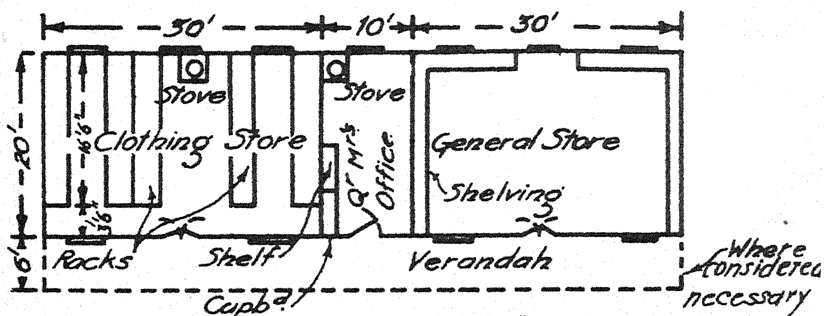
REG^TL. SHOPS & STORES.



Eaves height 8'-0"

—Fig. 1.—

Suitable for a Battalion.

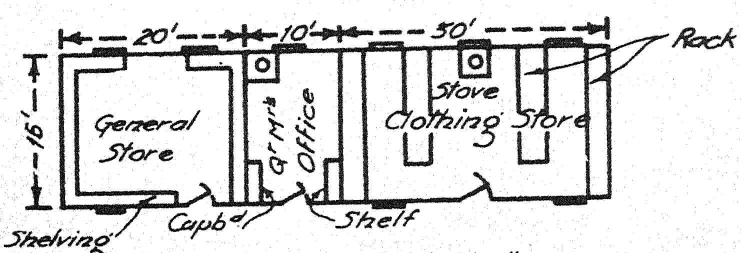


Eaves height 8'-0"

Swing windows in gable ends

—Fig. 2.—

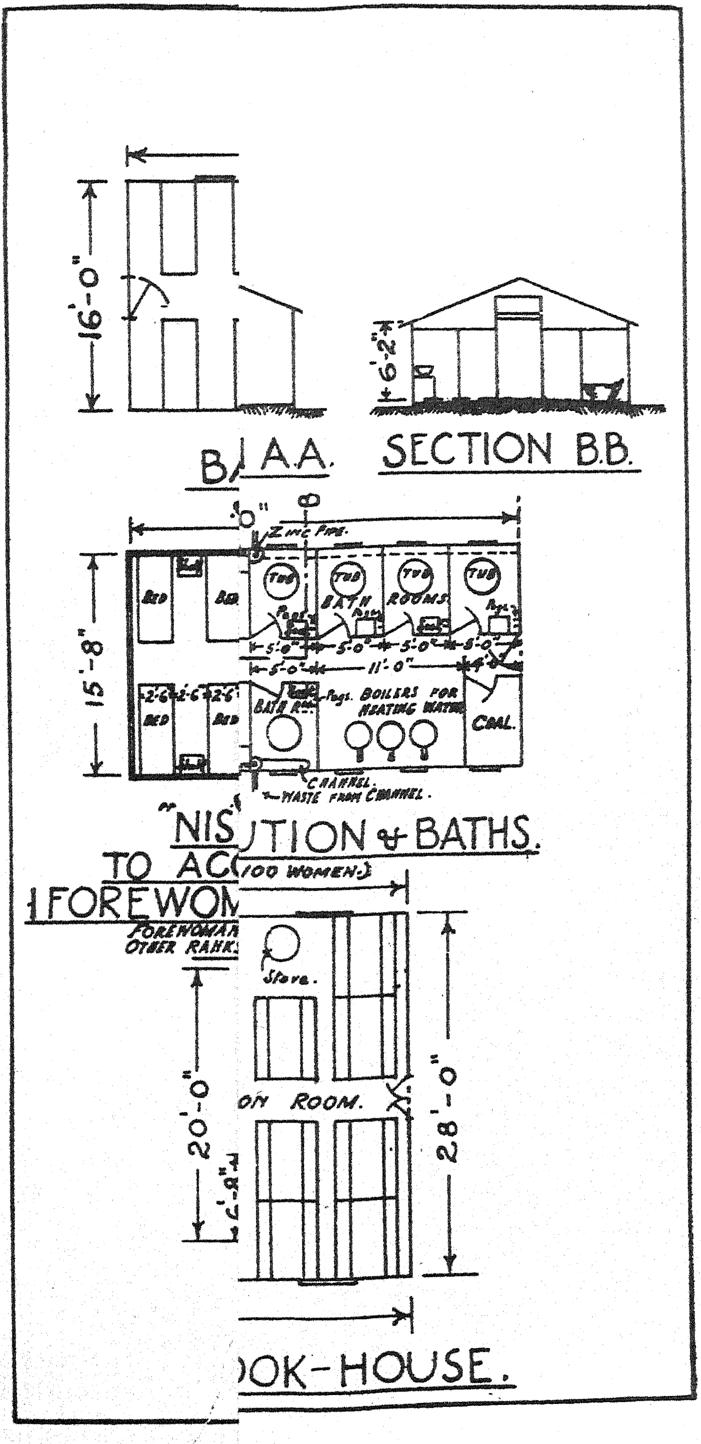
Suitable for a Depo
of 1000 Me



Eaves height 7'-6"

—Fig. 3.—

Suitable for a Battalion


16'-0"
B A.A.
SECTION B.B.
6'-2"
ZINC PIPE.
15'-8"
BED
BED
TUB
TUB
TUB
TUB
BATH ROOMS
Pegs.
5'-0"
11'-0"
2'-6"
BATH Rm.
Pegs. BOILERS FOR HEATING WATER
COAL.
CHANNEL.
WASTE FROM CHANNEL.
"NIS UTION & BATHS.
TO ACC (100 WOMEN.)
FOREWOM
FOREWOMAN
OTHER RANKS
Stove.
ON ROOM.
20'-0"
28'-0"
OOK-HOUSE.

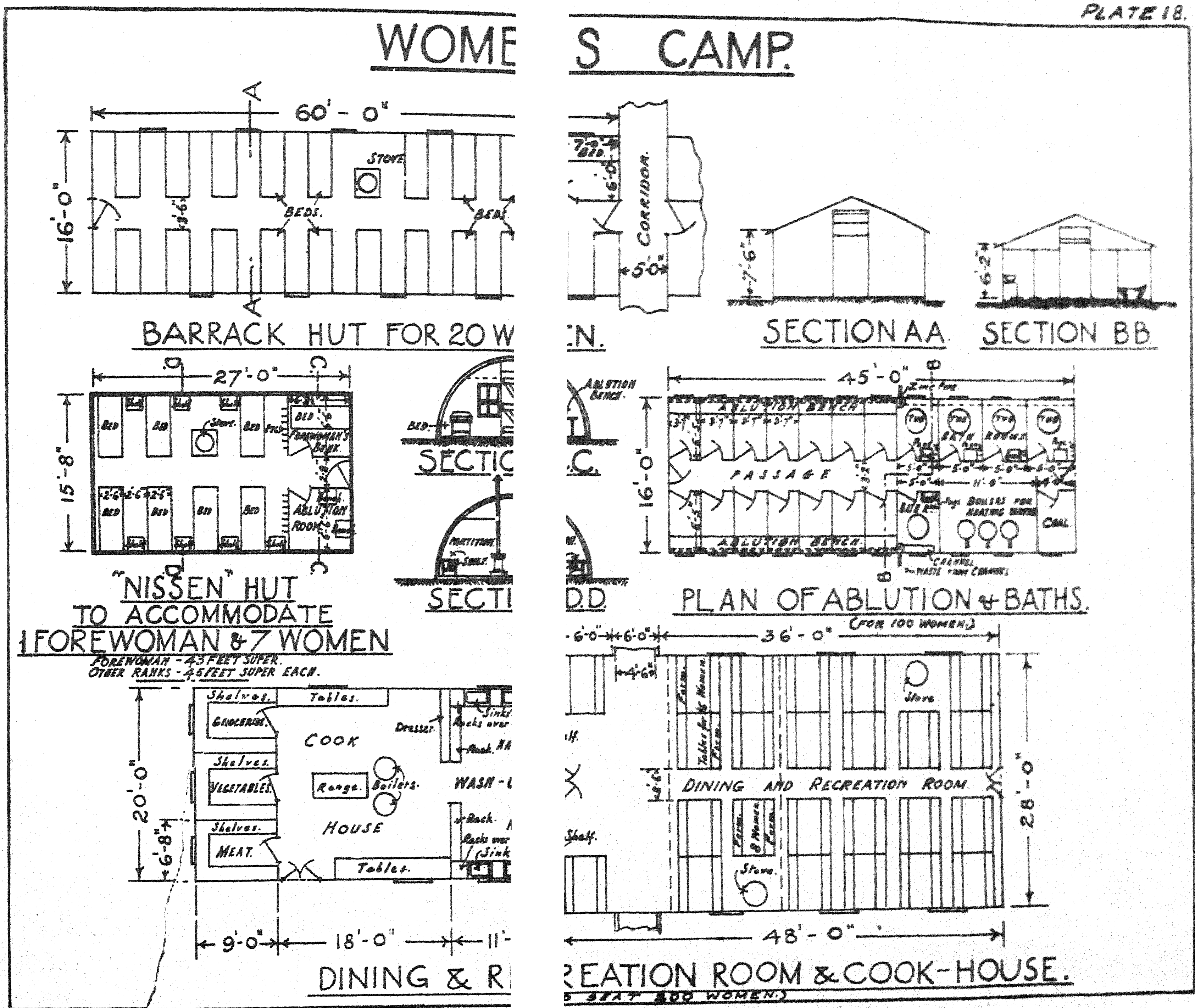
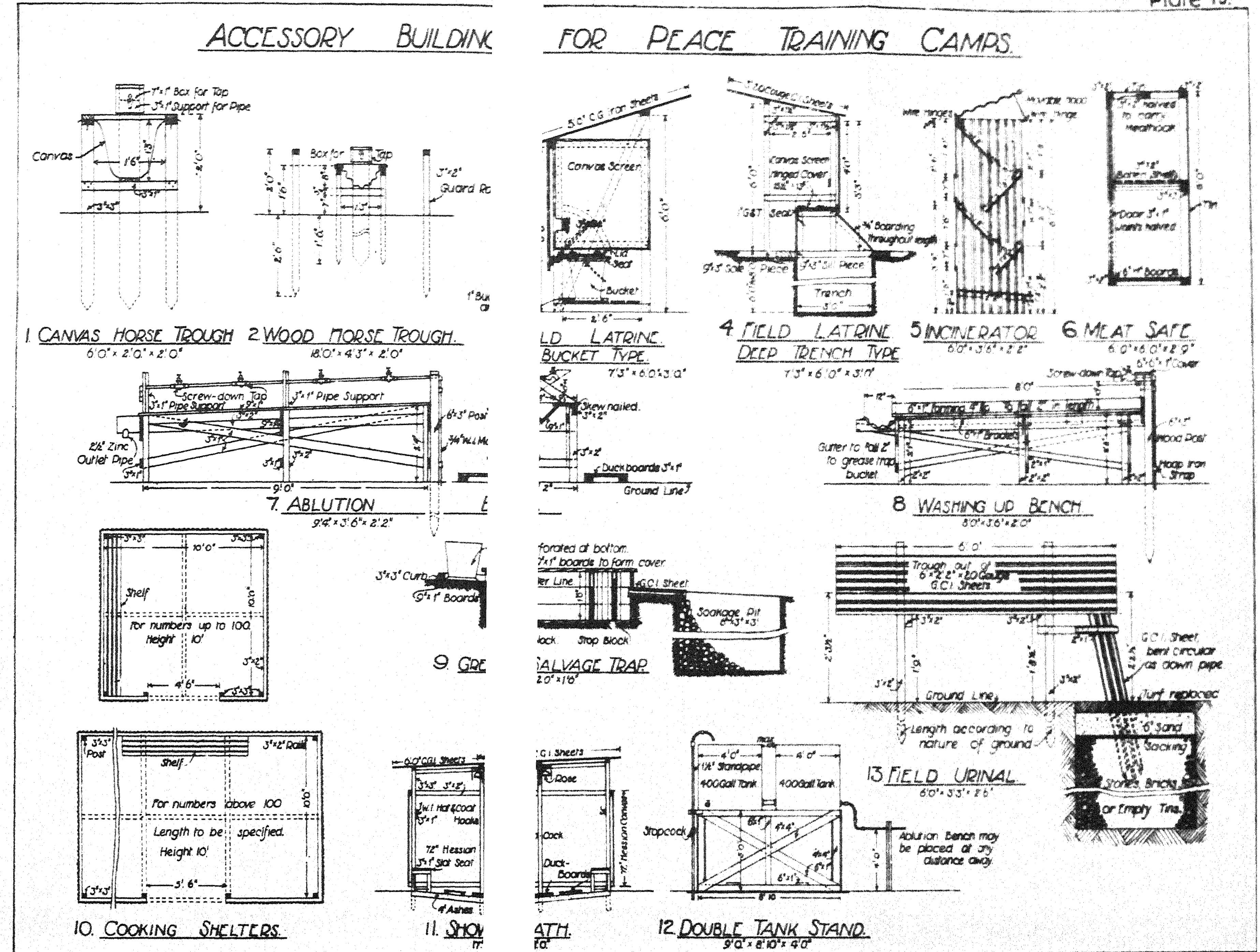

WOME S CAMP.
60'-0"
16'-0"
STOVE
BEDS.
3'-6"
7'-0"
BED.
6'-0"
CORRIDOR.
5'-0"
A
A
7'-6"
6'-2"
BARRACK HUT FOR 20 W N.
SECTION AA
SECTION BB
27'-0"
15'-8"
BED
Stove.
FOREWOMAN'S BUNK.
ABLUTION ROOM.
"NISSEN" HUT
TO ACCOMMODATE
1 FOREWOMAN & 7 WOMEN
FOREWOMAN - 43 FEET SUPER.
OTHER RANKS - 45 FEET SUPER EACH.
BED
SECTIC C.
PARTITION.
SHELF.
SECTI D.D.
ABLUTION BENCH.
45'-0"
16'-0"
ABLUTION BENCH
PASSAGE
TUB
BATH ROOMS
BOILERS FOR HEATING WATER
COAL
CHANNEL
WASTE FROM CHANNEL
PLAN OF ABLUTION & BATHS.
(FOR 100 WOMEN.)
6'-0"
6'-0"
36'-0"
4'-6"
Shelves.
Tables.
GROCERIES.
COOK
Dresser.
Sinks.
Racks over
Shelves.
VEGETABLES.
Range.
Boilers.
WASH -
Shelves.
MEAT.
HOUSE
Rack.
Racks over
Sink
Tables.
20'-0"
6'-8"
9'-0"
18'-0"
11'-
Stove.
Form.
Tables for 16 Women.
DINING AND RECREATION ROOM
8 Women
Stove.
Shelf.
28'-0"
48'-0"
DINING & R EATION ROOM & COOK-HOUSE.
SEAT 200 WOMEN.)

Plate 19.



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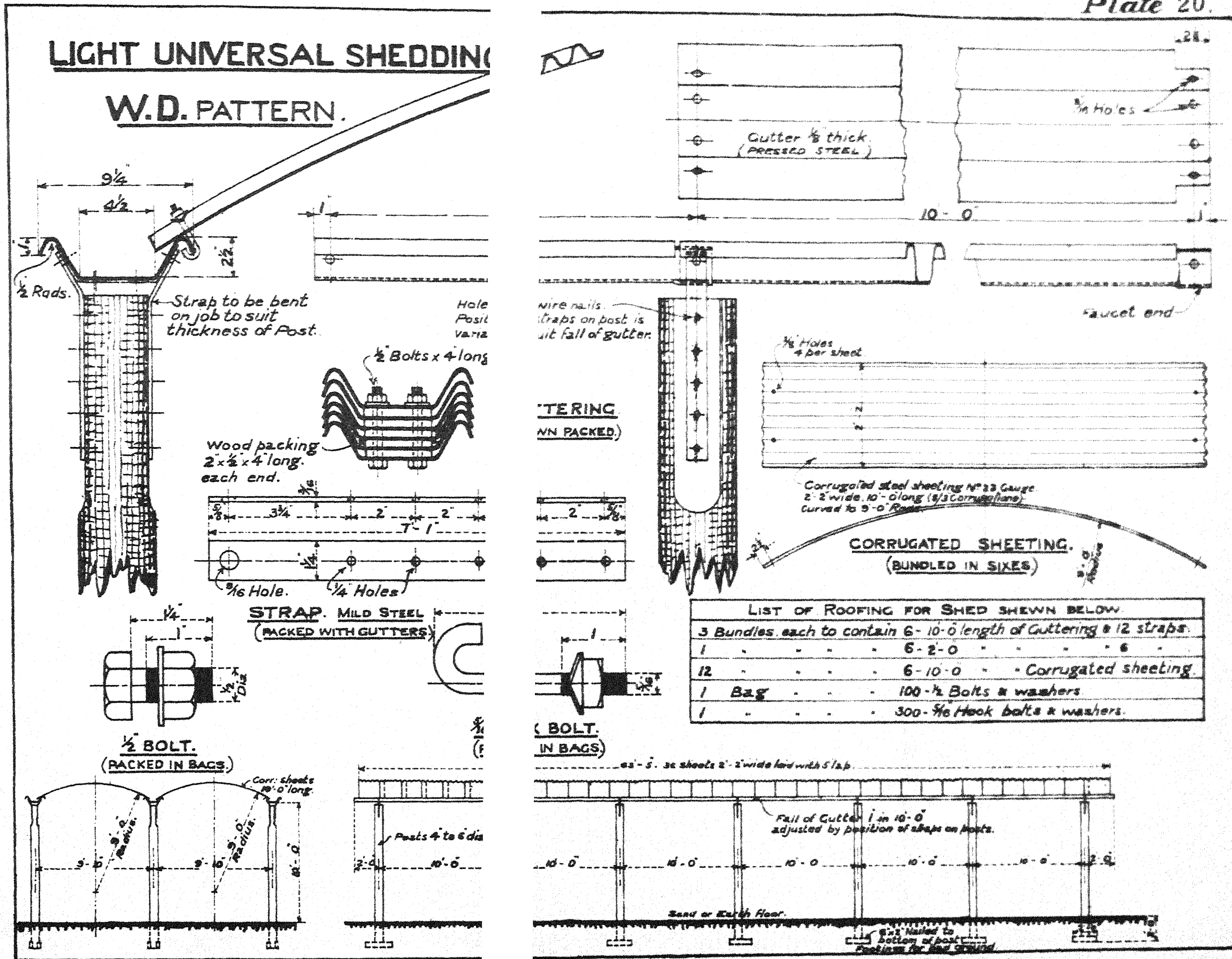
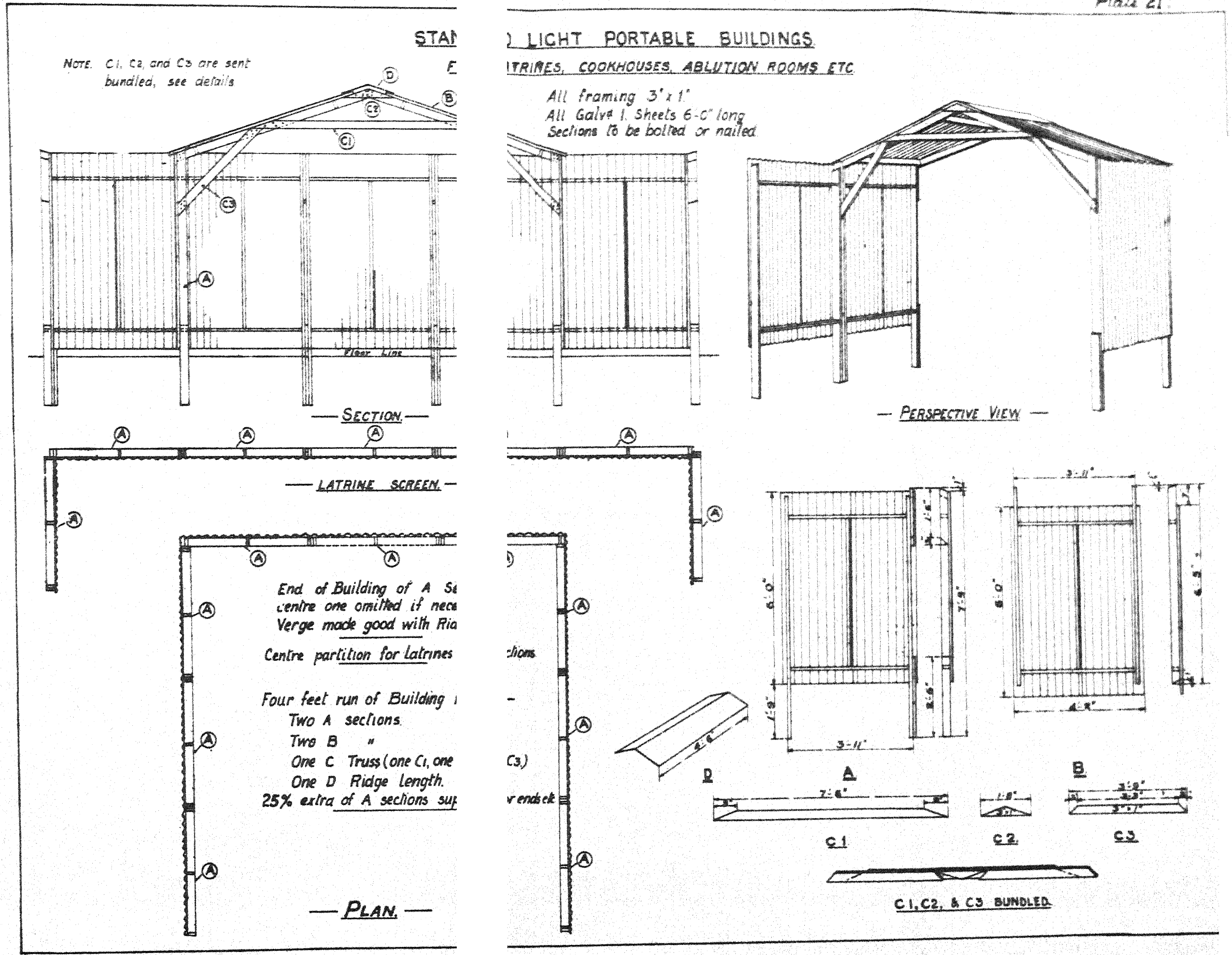
LIGHT UNIVERSAL SHEDDING

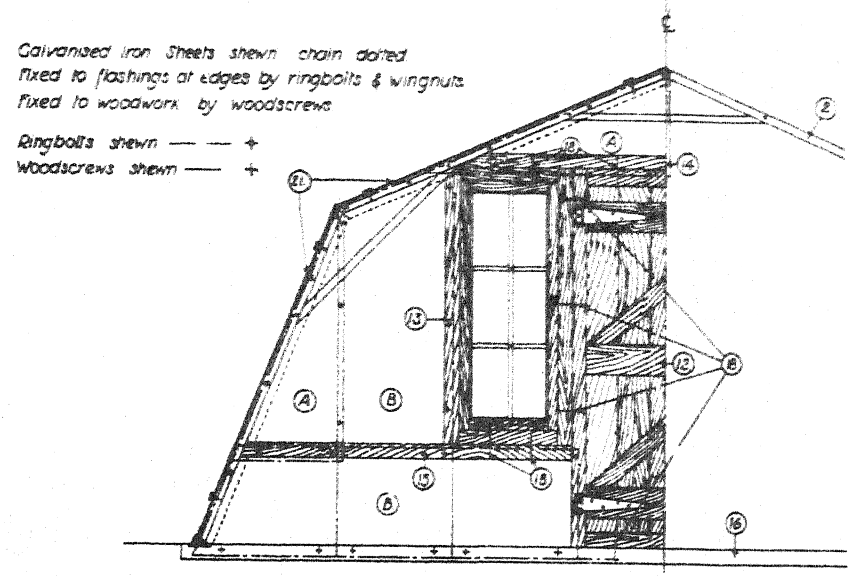
W.D. PATTERN.



LIST OF ROOFING FOR SHED SHEWN BELOW.		
3	Bundles each to contain	6 - 10 - 0 length of Guttering & 12 straps.
1	" " " "	6 - 2 - 0 " " " " 6 "
12	" " " "	6 - 10 - 0 " Corrugated sheeting.
1	Bag - - -	100 - ½ Bolts & washers.
1	" - - -	300 - 5/16 Hook bolts & washers.


STAN
LIGHT PORTABLE BUILDINGS
F
TRINES, COOKHOUSES, ABLUTION ROOMS ETC.
NOTE. C1, C2, and C3 are sent bundled, see details
All framing 3" x 1"
All Galvd. I. Sheets 6'-0" long
Sections to be bolted or nailed
D
C2
B
C1
C3
A
Floor Line
— SECTION —
— PERSPECTIVE VIEW —
— LATRINE SCREEN —
End of Building of A Se
centre one omitted if nece
Verge made good with Ri
Centre partition for latrines
ctions
Four feet run of Building
Two A sections.
Two B "
One C Truss (one C1, one
C3.)
One D Ridge length.
25% extra of A sections su
r ends etc
— PLAN. —
6'-0"
7'-9"
1'-6"
2'-6"
1'-9"
3'-11"
4'-6"
6'-5"
4'-4"
D
A.
B
7'-6"
1'-8"
C1
C2
C3
C1, C2, & C3 BUNDLED.

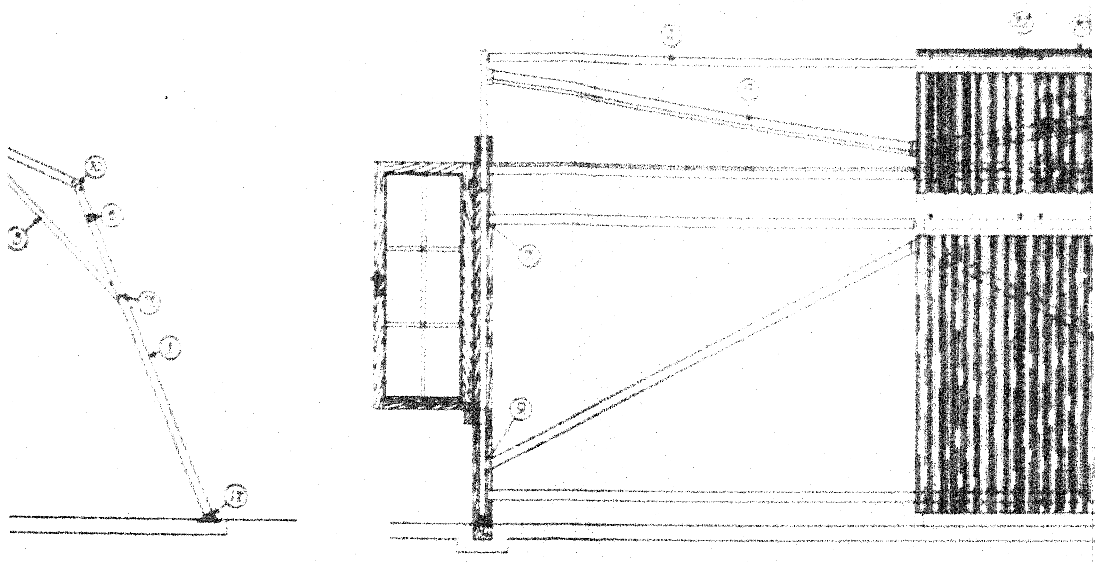
ADAMS HUT.



END ELEVATION.

GABLE END

INSIDE VIEW.

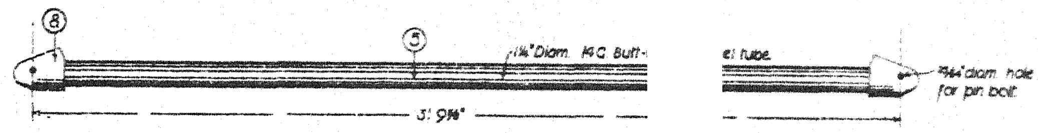


SIDE ELEVATION.

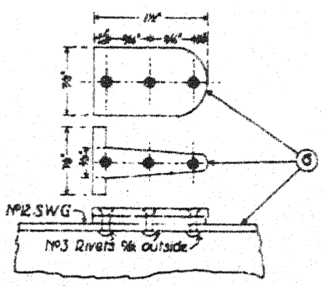
FRAME

GALV

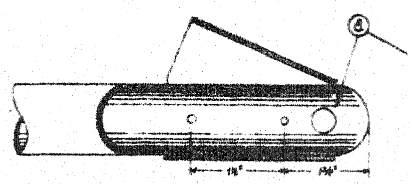
SCALE FOR END & SIDE ELEVATIONS



KNEE BRACE

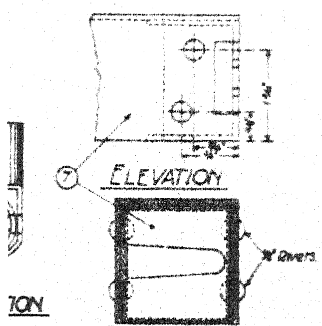


DETAILS OF JOINT. (MALE)



HALF SECTION. END

STAMPED STEEL GUSS



ELEVATION

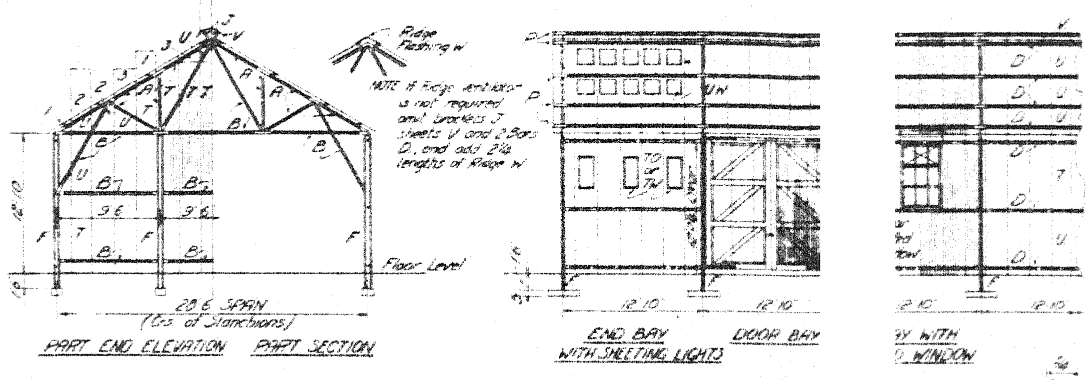
END ELEVATION.

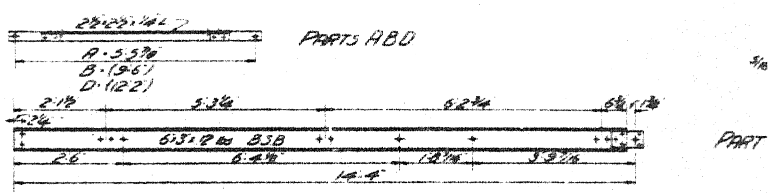
DETAILS OF JOINT (FEMALE)

PART LIST

ITEM	DESCRIPTION	MATERIAL	No. OFF	REMARKS
1	Upright	Steel 28-32 tons tensile [illegible]	[illegible]	Joined to frame member by [illegible]
2	Frame Member	"	[illegible]	Frame members joined by [illegible]
3	Purlin	"	[illegible]	Purlin joined to frame member [illegible]
4	Stay	"	[illegible]	Stay joined to frame members [illegible]
5	Knee Brace	Butt-welded Steel tube [illegible]	[illegible]	Joined to frame members by [illegible]
6	Male Joint	Steel plate [illegible]	[illegible]	
7	Female Joint	" [illegible]	[illegible]	
8	Gusset	"	[illegible]	
9	Female Joint (Swivel)	"	[illegible]	
10	Frame Joint	Cast Brass	[illegible]	
11	Pin bolt and Split Pin	Mild Steel	[illegible]	
12	Door and Frame	Timber Oregon Pine	[illegible]	Joined to top and bottom sill and [illegible]
13	Window and Frame	"	[illegible]	Joined to top sill, [illegible]
14	Top Sill	"	[illegible]	
15	Intermediate Sill	"	[illegible]	Joined to door and window frame
16	Bottom Sill	"	[illegible]	
17	Shoe	Mild Steel	[illegible]	Attached to bottom sill [illegible]
18	Bolted Joint	" bolt [illegible]	[illegible]	[illegible] head and nut with [illegible]
19	Corrugated Sheets	Galvanised Iron [illegible]	[illegible]	Fixed with 24 and [illegible]
20	Ridge Sheets	" [illegible]	[illegible]	Fixed with 24 and fastened to [illegible]
21	Flashings	[illegible]	[illegible]	
22	Hook Bolts	[illegible]	[illegible]	
23	Ring Bolts	[illegible]	[illegible]	
24	Eyelets	[illegible] O.D. Solid drawn steel tube [illegible]	[illegible]	
A	Gable Sheets	Galvanised Iron [illegible]	4	Joined by 23 and [illegible]
B	" "		4	woodscrews with galvanised [illegible]
	Woodscrews	Galv'd [illegible] with Rubber & Galv'd washers	[illegible]	rubber washers under [illegible]

HUT 28'-6" SPAN 12'-10" HIGH (S[illegible]L)





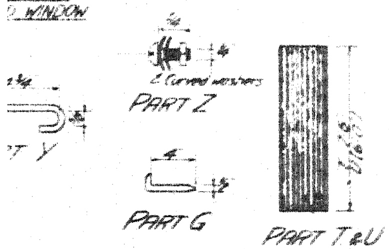


TABLE 1 QUANTITIES PER BAY & ENDS WITH VENTILATOR BUT WITHOUT DOORS & WINDOWS			
MARK	Nº PER BAY	ENDS	DESCRIPTION
A	10	10	FRAMING BARS 5'5⅞ CRS OF EYES
B	7	19	" " 9'6
D	16		" " 12'2
F	2	6	STANCHIONS 6'3"x12 lbs B.S.B.
G	5	24	SPIKES 4"x½ FOR STANCHIONS
H	8	8	PURLIN CLEATS
J	2	2	VENTILATOR BRACKETS
L	43	43	BOLTS & NUTS ⅝"x1¼ DIA
M	141	175	WASHERS 2¼"x½ FOR "
N	32	40	BOLTS & NUTS [illegible] DIA FOR PURLIN CLEATS
O		20	PURLIN EXTENSION
Q	16	12	FRAMING CLEATS
T	13	42	GALVᴰ CORRᴰ SHEETS 7'6"x19"x24 G
U	52	35	" " " 6'0 "
		4	" " " 7'6 " CUT
		9	" " " 6'0 " CUT
V	52	1	" " CURVED 3'0 "
Y	208	276	HOOK BOLTS & WASHERS
Z	570	440	SHEETING BOLTS & WASHERS

EXAMPLE

1	2	3	4	5	6	7

HUT SAY 7 BAYS

FOR A HUT COMPLETE OF SAY 7 BAYS CLOSED AT BOTH ENDS, QUANTITIES REQUIRED WILL BE 7 TIMES Nº PER BAY, PLUS ENDS.

LIST FOR ORDERING

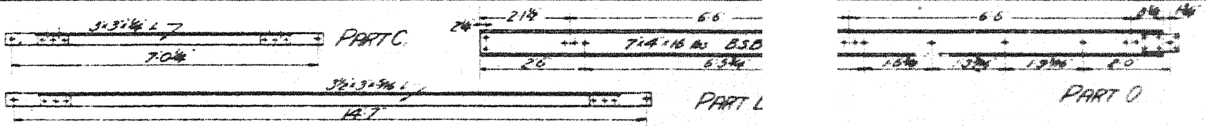
WOOD FRAME [illegible]

WOOD WIND[illegible]

CORRUGATED SHEET[illegible]

MATERIALS REQ. FOR 1 PAIR OF W[illegible]

MATERIALS REQUIRED FOR 1 WOOD [illegible]



NOTE

QUANTITIES ARE NET. SPARE PARTS SHOULD BE ADDED TO COVER LOSS.
ALTERNATIVE RIDGE DETAIL IF VENTILATOR IS NOT REQUIRED.
FOR EACH DOOR AND WINDOW DEDUCTIONS CAN BE MADE FROM THE QUANTITIES OF SHEETING, FRAMING BARS, ETC IN THE LIST.

LIST FOR ORDERING

WOOD WIN[illegible]

CORRUGATED SHEET[illegible]

MATERIALS REQ. FOR 1 PAIR OF W[illegible] IF MADE ON S[illegible]

STILES
TOP & BOTTOM RAILS
MIDDLE RAILS
BRACES
SHEETING FILLETS
HINGES EACH WITH BOLTS & WASHERS
HINGE BRACKETS WITH NUTS
STRIKING PLATES
LOCK COMPLETE WITH PLATE
GALVᴰ CORRᴰ SHEETS
SPIKES NAILS ETC AS REQUIRED

MATERIALS REQUIRED FOR 1 WOO[illegible]

FRAME
SASH
SILL
FILLET
GLAZING BARS
TOP FILLING
CLAMPS WITH WOOD SCREWS
FANLIGHT BUTTS
CATCH
HOPPER CHEEKS
PANES 4TH QUALITY
NAILS & PUTTY ETC AS
BOTTOM FILLING

HUT 36'-6" SPAN 14'-6" HIGH (S[illegible]L)

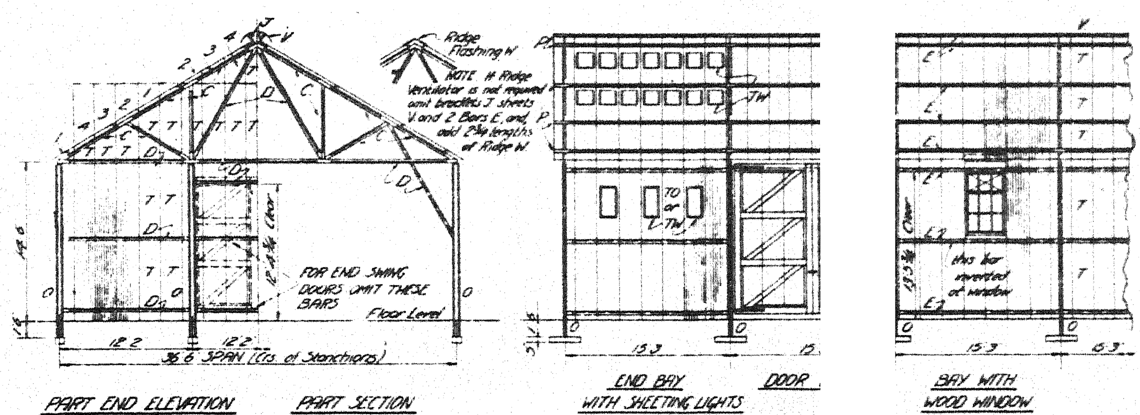
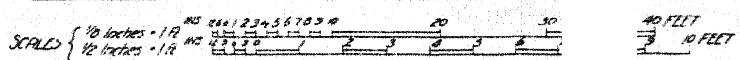
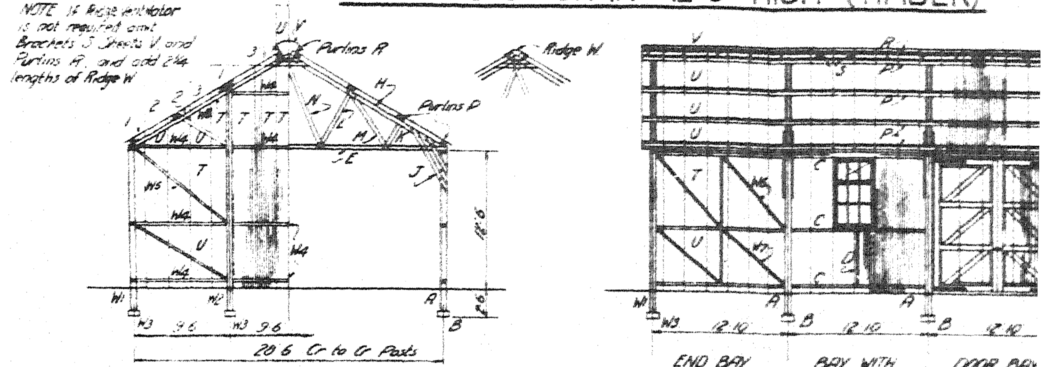


TABLE 2 QUANTITIES PER BAY & ENDS WITH VENTILATOR BUT WITHOUT DOORS & WINDOWS			
MARK	Nº PER BAY	ENDS	DESCRIPTION
C	10	10	FRAMING BARS 7'0¼ CRS OF EYES
D	7	15	" " 12'2
E	16		" " 14'7
G	8	34	SPIKES 4"x½ FOR STANCHIONS
H	8	8	PURLIN CLEATS
J	2	2	VENTILATOR BRACKETS
L	43	48	BOLTS & NUTS ⅝"x1¼ DIA
M	141	185	WASHERS 2¼"x½ FOR "
N	32	40	BOLTS & NUTS [illegible] DIA FOR PURLIN CLEATS
O	2	6	STANCHIONS 7'4"x16 lbs B.S.B.
P		20	PURLIN EXTENSION
Q	16	12	FRAMING CLEATS
T	78	106	GALVᴰ CORRᴰ SHEETS 7'6"x19"x24 G
T		16	" " " CUT
V	7¾	1	" CURVED 3'0"x19"x24 G
Y	256	342	HOOK BOLTS & WASHERS
Z	735	1160	SHEETING BOLTS & WASHERS

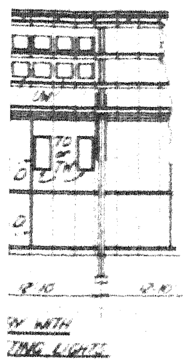
WOOD FRAME SWING DOORS		
	PAIR	RIGHT HAND LEAF WITH PADLOCK } PAIRS AS REQUIRED LEFT



HUT 28'-6" SPAN 12'-6" HIGH (TIMBER)



PART END ELEVATION   PART SECTION



	GALVANIZED CORRUGATED SHEETING LIGHTS	
TO	GALV^D CORR^D SHEETING LIGHT 7'6 WITH GLASS	OPENING
TW	7'6	FIXED
UO	6'0	OPENING
UW	6'0	FIXED

MARK	Nº PER BAY	ENDS	GALVANIZED CORRUGATED SH...
T	13	42	SHEETS 7'6 × 8/3 CORRUGATIONS
U	52	38	6'0
V	6¼	1	CURVED 3'0"
	1½	2	GROSS CONE HEADED NAILS & ...
Z	570	840	SHEETING BOLTS & WASHERS

EXAMPLE

1	2	3	4	5	6	7

HUT SAY 7 BAYS

FOR A HUT COMPLETE OF SAY 7 BAYS CLOSED AT BOTH ENDS QUANTITIES REQUIRED WILL BE 7 TIMES QUANTITIES PER BAY PLUS ADDITIONAL PARTS FOR ENDS

LIST FOR ORDERING 28'6" SPAN

1 PAIR SIDE SWING DOORS (IF MADE AT SITE)		
4	STILES & TOP & BOTTOM RAILS	6×3×12 0
4	MIDDLE RAILS	5×2×5 4
6	BRACES	5×2×6 3
12	SHEETING FILLETS	2½×1×3 3
4	SHEETING FILLETS	2½×1×4
4	HINGES EACH WITH BOLTS & WASHERS	
4	HINGE BRACKETS WITH NUTS	
4	STRIKING PLATES 3×3×¼ WITH WOOD SCREWS	
1	LOCK COMPLETE WITH PLATE WOOD SCREWS & PADLOCK	
10	GALV^D CORR^D SHEETS 6'0 ×8/3 ×24 G	
	SPIKES NAILS ETC AS REQUIRED	

1 WOOD WINDOW (IF MADE AT SITE)		
1	FRAME	3×3×16 11
1	SASH	2½×1¾×26 0
1	SILL	6×3×3 10
1	SILL FILLET	1½×1½×3 10
1	GLAZING BARS	1¾×1×14 6
1	TOP FILLING	5×2×1 4
1		4×1×7 8
4	CLAMPS WITH WOOD SCREWS	
2	FANLIGHT BUTTS	
1	CATCH	
2	HOPPER CHEEKS	
9	PANES 4TH QUALITY 15 OZ SHEET GLASS	
	NAILS PUTTY ETC AS REQUIRED	

NOTE

QUANTITIES ARE NETT –
ALTERNATIVE RIDGE DETAIL IF VENTILATOR IS NOT REQUIRED –
FOR EACH DOOR AND WINDOW DEDUCTIONS CAN BE MADE FROM THE QUANTITIES OF RAILS FRAMING SHEETING ETC IN THE LIST –

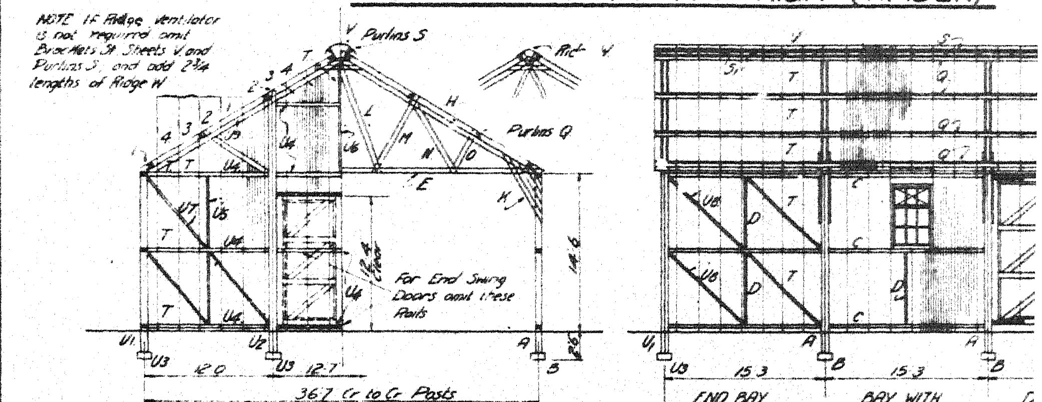
TABLE 1		QUANTITIES PER BAY (NETT)			
MARK	Nº	DESCRIPTION	TIMBER	LENGTH	POSITION
[illegible]	4	POSTS (FIXED IN PAIRS)	[illegible]	[illegible]	TO SIDE
[illegible]	4	PIECES SPIKED ON AT BOTTOM	[illegible]	[illegible]	
[illegible]	[illegible]	RAILS	[illegible]	[illegible]	
[illegible]	[illegible]	FRAMING (TO CUT)	[illegible]	[illegible]	
[illegible]	[illegible]	TIE BEAMS (SCARFED)	[illegible]	[illegible]	ROOF TRUSS
[illegible]	4	SCARFING PIECES	[illegible]	[illegible]	
[illegible]	4	DISTANCE PIECES	[illegible]	[illegible]	
[illegible]	[illegible]	RAFTERS	[illegible]	[illegible]	
[illegible]	4	DISTANCE PIECES [illegible] APEX & SHOE	[illegible]	[illegible]	
[illegible]	4	KNEE BRACES (TO CUT)	[illegible]	[illegible]	
[illegible]	[illegible]	STRUTS	[illegible]	[illegible]	
[illegible]	[illegible]	STRUTS	[illegible]	[illegible]	
[illegible]	[illegible]	BRACES	[illegible]	[illegible]	
[illegible]	[illegible]	BRACES	[illegible]	[illegible]	
[illegible]	[illegible]	BATTENS AT APEX (TO CUT)	[illegible]	[illegible]	
[illegible]	[illegible]	PURLINS	[illegible]	[illegible]	
[illegible]	[illegible]	PURLIN JOINTS	[illegible]	[illegible]	
[illegible]	[illegible]	PURLINS TO VENTILATOR	[illegible]	[illegible]	
[illegible]	[illegible]	PURLIN SUPPORTS (TO CUT)	[illegible]	[illegible]	
	29	lbs OVAL WIRE NAILS	[illegible]		

ADDITIONAL PARTS FOR TWO END FRAMES					
W1	4	POSTS (FIXED IN PAIRS)	[illegible]	[illegible]	TO END
W2	[illegible]	POSTS (FIXED IN PAIRS)	[illegible]	[illegible]	
W3	[illegible]	PIECES SPIKED ON AT BOTTOM	[illegible]	[illegible]	
W4	20	RAILS	[illegible]	[illegible]	
W5	[illegible]	CROSS BRACING ENDS	[illegible]	[illegible]	TO SIDE
W6	[illegible]	CROSS BRACING SIDES	[illegible]	[illegible]	
W7	[illegible]		[illegible]	[illegible]	TO END
W8	[illegible]	RAFTERS	[illegible]	[illegible]	
W9	[illegible]	PURLIN JOINTS	[illegible]	[illegible]	
W10	[illegible]	PURLIN EXTENSION TO VENTILATOR	[illegible]	[illegible]	
	[illegible]	lbs OVAL WIRE NAILS	[illegible]		

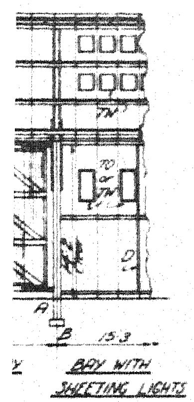
	WOOD WINDOWS
	WINDOW COMPLETE WITH GLASS) Nº AS REQUIRED

	WOOD FRAME SWING DOORS
PAIR	RIGHT HAND LEAF WITH PAD... LEFT
	PAIRS AS REQUIRED

HUT 36'-7" SPAN 14'-6" HIGH (TIMBER)



PART END ELEVATION   PART SECTION



	GALVANIZED CORRUGATED SHEETING LIGHTS	
TO	GALV^D CORR^D SHEETING LIGHT 7'6 WITH GLASS	OPENING
TW	7'6	FIXED
UO	6'0	OPENING
UW	6'0	FIXED

MARK	Nº PER BAY	ENDS	GALVANIZED CORRUGATED SH...
T	78	106	SHEETS 7'6 × 8/3 CORRUGATI...
U		16	
V	7¾	1	CURVED 3'0"
	2	2½	GROSS CONE HEADED NAILS
Z	735	1160	SHEETING BOLTS & WASHERS

SCALE ⅛ INCH = 1 FOOT

LIST FOR ORDERING 36'-7" SPAN

1 PAIR END SWING DOORS (IF MADE AT SITE)		
6	STILES & TOP & BOTTOM RAILS	6×3×12 0
4	MIDDLE RAILS	5×2×5 4
6	BRACES	5×2×6 0
12	SHEETING FILLETS	2½×1×3 3
4	SHEETING FILLETS	2½×2×4 0
4	HINGES EACH WITH BOLTS & WASHERS	
4	HINGE BRACKETS WITH NUTS	
4	STRIKING PLATES 3×3×¼ WITH WOOD SCREWS	
1	LOCK COMPLETE WITH PLATE WOOD SCREWS & PADLOCK	
10	GALV^D CORR^D SHEETS 6'0 ×8/3 ×24 G	
	SPIKES NAILS ETC AS REQUIRED	

1 PAIR SIDE SWING DOORS (IF MADE AT SITE)		
4	STILES	6×3×13 6
4	TOP & BOTTOM RAILS	6×3×7 2½
4	MIDDLE RAILS	5×2×6 6½
6	BRACES	5×2×7 [illegible]
12	SHEETING FILLETS	2½×2×3 11
4	SHEETING FILLETS	2½×2×3 0
4	HINGES EACH WITH BOLTS & WASHERS	
4	HINGE BRACKETS WITH NUTS	
4	STRIKING PLATES 3×3×¼ WITH WOOD SCREWS	
1	LOCK COMPLETE WITH PLATE SCREWS & PADLOCK	
6	GALV^D CORR^D SHEETS 6'0 ×8/3 ×24 G	
6	GALV^D CORR^D SHEETS 7'6 ×8/3 ×24 G	
	SPIKES NAILS ETC AS REQUIRED	

1 WOOD WINDOW (IF MADE AT SITE)		
1	FRAME	3×3×16 11
1	SASH	2½×1¾×26 0
1	SILL	6×3×3 10
1	SILL FILLET	1½×1½×3 10
1	GLAZING BARS	1¾×1×14 6
1	TOP FILLING	5×2×1 10
1	TOP FILLING	4×1×1 6
4	CLAMPS WITH WOOD SCREWS	
2	FANLIGHT BUTTS	
1	CATCH	
2	HOPPER CHEEKS	
9	PANES 4TH QUALITY 15 OZ SHEET GLASS	
	NAILS PUTTY ETC AS REQUIRED	

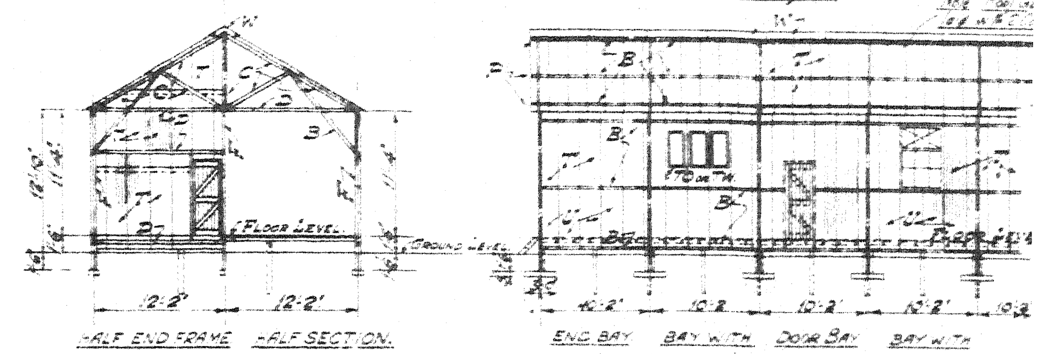
TABLE 2		QUANTITIES PER BAY (NETT)			
MARK	Nº	DESCRIPTION	TIMBER	LENGTH	POSITION
A	4	POSTS (FIXED IN PAIRS)	7×4	7 0	TO SIDE
B	4	PIECES (SPIKED ON AT BOTTOM)	7×4	13 8½	
C	6	RAILS	7×4	14 7	
D	2	FRAMING (TO CUT)	5×2	3 4	
E	2	TIE BEAMS (SCARFED)	5×2	37 6	ROOF TRUSS
F	4	SCARFING PIECES TO TIE BEAMS	5×2	2 6	
G	4	DISTANCE PIECES	5×2	4 0	
H	4	RAFTERS	5×2	21 0	
J	4	DISTANCE PIECES AT APEX	5×2	2 6	
K	4	SCARFING PIECES AT SHOE	5×2	4 0	
L	4	KNEE BRACES (TO CUT)	5×2	2 0	
M	2	BRACES	5×2	6 9	
N	2	STRUTS	5×2	8 6	
O	2	BRACES	5×2	8 6	
P	2	STRUTS	5×2	5 0	
Q	2	BATTENS AT APEX (TO CUT)	5×2	2 6	
R	8	PURLINS	7×4	15 3	ROOF
S	8	PURLIN JOINTS	5×2	2 6	
S	2	PURLINS TO VENTILATOR	2×2	15 3	
S		PURLIN SUPPORTS (TO CUT)	3×2	12 0	
	40	lbs CUT NAILS	6 Long		
	5	lbs OVAL WIRE NAILS	4 Long		

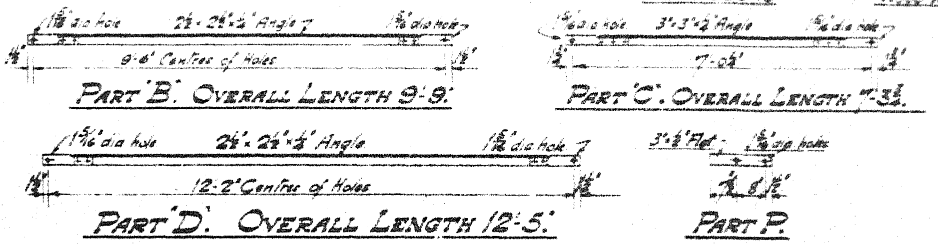
ADDITIONAL PARTS FOR TWO END FRAMES					
U1	4	POSTS (FIXED IN PAIRS)	7×4	7 0	TO END
U2	2	POSTS (FIXED IN PAIRS)	7×4	8 0	
U3	2	PIECES SPIKED ON AT BOTTOM	7×4	13 8½	
U4	20	RAILS	7×4	12 0	
U5	6	FRAMING (TO CUT)	5×2	13 4	
U6	2	FRAMING (TO CUT)	5×2	10 6	
U7	4	CROSS BRACING ENDS	5×2	9 0	
U8	4	CROSS BRACING SIDES	5×2	10 6	TO SIDE
U9	4	RAFTERS	5×2	8 0	TO END
U10	8	PURLIN JOINTS	5×2	2 6	
U11	4	PURLIN EXTENSION TO VENTILATOR	2×2	2 6	
	61	lbs CUT NAILS	4 Long		
	6	lbs OVAL WIRE NAILS	3 Long		

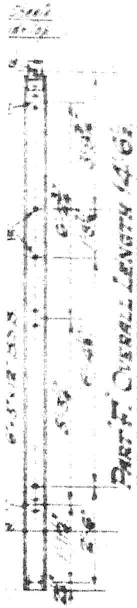
	WOOD WINDOWS
	WINDOW COMPLETE WITH GLASS) Nº AS REQUIRED

	WOOD FRAME SWING DOORS
PAIR	RIGHT HAND LEAF WITH PAD... LEFT
	PAIRS AS REQUIRED

HUT. 24'-4" SPAN. 12'-10" HIGH. (STEEL.)







LIST FOR ORDERING. STEEL HUT.

TABLE "A". QUANTITIES PER BAY AND FOR ENDS

Mark	No. Per Bay	No. Both Ends	Description
B	4	2	Framing bars 9'6" centres of holes
C	[illegible]	[illegible]	" " 7'0½" "
D	[illegible]	[illegible]	" " 12'2" "
F	[illegible]	4	Stanchions 6'3" x 7" B.S.B.
G	[illegible]	16	Screws 2" x ¾" for stanchions
H	6	6	Purlin cleats
L	52	28	Bolts & nuts 5" x ½"
M	114	83	Washers 2½" x ⅛" for ditto
N	28	20	Bolts & washers ⅝" long x ⅜" dia
P	–	12	Purlin extensions
S	16	8	Framing cleats
T	34	62	Galvd corrd sheets 7'6" x 8/3" x 24G
U	10	–	" " " 6'0" " "
W	2	–	Galvd flashing 6'0" x 20G x 2'0" [illegible]
Y	140	200	Galvd hook bolts & washers 4½" x [illegible]
Z	342	590	Galvd sheeting bolts & washers [illegible]

QUANTITIES FOR TIMBER IN FLOOR (PER BAY)

Description	Scantling		Nett
Sleepers for stanchion bases	10" x 5"	Feet Run	6
Stumps	6" x 3"	" "	31
Plates and joists	4" x 2"	" "	245
Floor boards	1"	Ft Super	250
Ladder	7" x 1"	Feet Run	75
Flooring brads 2½"	–	LBS	4
Cut nails 4"	–	"	6

NOTE. QUANTITIES ARE NETT. SPARE PARTS SHOULD BE ADDED TO COVER LOSS.

FOR EACH DOOR & WINDOW, DEDUCTIONS CAN BE MADE FROM THE QUANTITIES OF SHEETING BARS ETC.

QUANTITIES IN ONE SINGLE DOOR IN TIMBER 2'6" x 6'8"

Description	Scantling		Nett
Top middle & bottom rails	[illegible]	Feet Run	[illegible]
Styles	[illegible]	"	[illegible]
Braces	[illegible]	"	[illegible]
Strip	[illegible]	"	[illegible]
Boarding T&G	[illegible]	"	40
Butts W.I. 3"	–	No of Pairs	1
Latch Norfolk lock & furniture	–	No	1
Zinc flashing 8" wide	–	Feet Run	3
Wire nails 2"	–	LBS	2

QUANTITIES IN ONE WOOD WINDOW

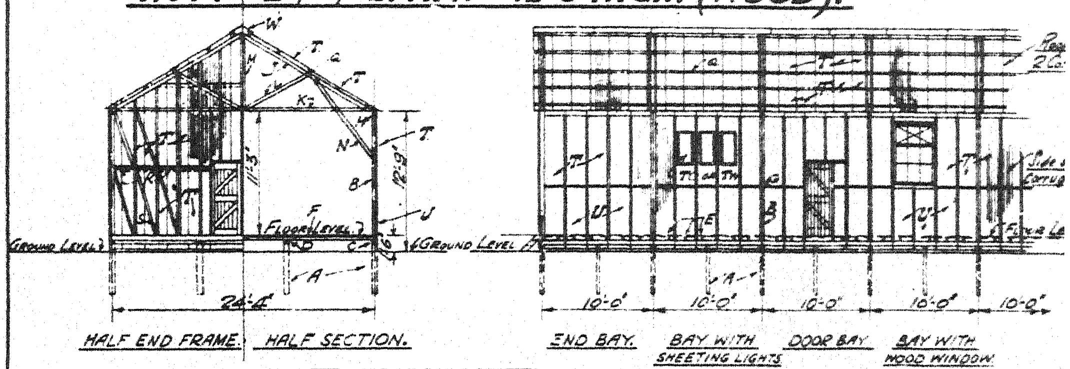
Description	Scantling		Nett
Frame	3" x 3"	Feet Run	21'0"
Sash	[illegible]	"	26'0"
Sill	6" x 3"	"	3'10"
Sill fillet	[illegible]	"	3'10"
Glazing bar	[illegible]	"	[illegible]
Top filling	[illegible]	"	[illegible]
" "	[illegible]	"	[illegible]
Clamps with woodscrews	–	No	4
Fanlight butts	–	"	2
Hopper cheeks	–	"	2
Panes 4th quality 15oz sheet glass	–	"	3
Nails putty etc as required, & one fanlight catch			

EXAMPLE.

End Bay	Bay	End Bay				
1	2	3	4	5	6	7

NOTE. FOR A HUT COMPOSED OF SAY SEVEN BAYS CLOSED AT BOTH ENDS, THE TOTAL QUANTITIES REQUIRED WILL BE 7 TIMES THE QUANTITIES PER BAY IN TABLE "A" PLUS THE QUANTITIES FOR BOTH ENDS.

HUT. 24'-4" SPAN. 12'-9" HIGH. (WOOD).



HALF END FRAME. HALF SECTION.

END BAY. BAY WITH SHEETING LIGHTS. DOOR BAY. BAY WITH WOOD WINDOW.

EXAMPLE.

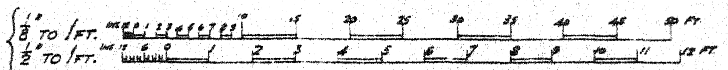
10'-0" Bay	10'-0" Bay	10'-0" Bay	10'-0" Bay	10'-0" Bay	10'-0" Bay	10'-0" Bay
1	2	3	4	5	6	7

NOTE. FOR A HUT COMPOSED OF, SAY, SEVEN BAYS, CLOSED AT BOTH ENDS, THE TOTAL QUANTITIES REQUIRED WILL BE 7 TIMES THE QUANTITIES PER BAY PLUS THE QUANTITIES FOR BOTH ENDS.

QUANTITIES PER BAY & FOR ENDS. ROOF & SIDE CO[VERING]

Mark	No. Per Bay	No. Both Ends	Description
T	34	62	Galvd Corrd Sheets 7'-6", 8/3" x
U	10	–	" " " 6'-0"
W	2	–	Galvd Flashing, 6'-0" x 20 Gauge x
	180	200	Galvd Spike Nails & Washers
Z	342	590	Galvd Sheeting Bolts & Washer

SCALE: ⅛" TO 1 FT. ½" TO 1 FT.



LIST FOR ORDERING. WOOD HUT.

QUANTITIES PER BAY (NETT)

Mark	Number	Description	Length	Position
A	8	Stumps 6" x 3"	5'-0"	
B	12	Uprights 4" x 2"	11'-10"	Main Frame
C	4	Cills 4" x 2"	11'-6"	" "
D	4	Plates 4" x 2"	11'-6"	Floor
E	7	Joists 4" x 2"	24'-6"	"
F	–	4" x 1" T&G Boarding (wrot one side)	245 Sup Ft	"
G	–	Side rails 4" x 2"	21'-8"	Framing
H	4	Beams under trusses 4" x 2"	11'-6"	"
J	4	Rafters 4" x 1½"	14'-3"	Roof
K	2	Bottom ties 4" x 1½"	25'-0"	"
L	4	Web members 4" x 1½"	7'-6"	"
M	2	" " "	7'-0"	"
N	4	Knee braces 4" x 1½"	11'-0"	"
O	8	Scarfing pieces 4" x 1½"	2'-6"	"
P	–	Packing pieces " "	20 Lin Ft	"
Q	10	Purlins 4" x 2"	10'-0"	"
	–	Purlin joints & brackets	20 Lin Ft	"
	–	Oval wire nails 4" long	30 LBS	
	–	Flooring brads 2½"	4 LBS	Floor

QUANTITIES IN TWO ENDS (NETT)

Mark	Number	Description		Position
A	4	Stumps 6" x 3"	5'-0"	End Frame
B	–	Uprights 4" x 2"	446 Lin Ft	"
C	3	Cills 4" x 2"	25'-0"	"
R	–	End rails 4" x 2"	90 Lin Ft	"
S	–	Braces 4" x 2"	120 Lin Ft	"
V	–	Ladders 7" x 1"	75 " "	"
J	4	Rafters 4" x 1½"	14'-3"	End Trusses
K	2	Bottom ties 4" x 1½"	25'-0"	" "
L	4	Web members 4" x 1½"	7'-6"	" "
M	2	" " "	7'-0"	" "
	–	Corner braces "	11'-0"	" "
	8	Scarfing pieces "	2'-6"	" "
	–	Packing pieces "	20 Lin Ft	" "
	–	Oval wire nails	40 LBS	

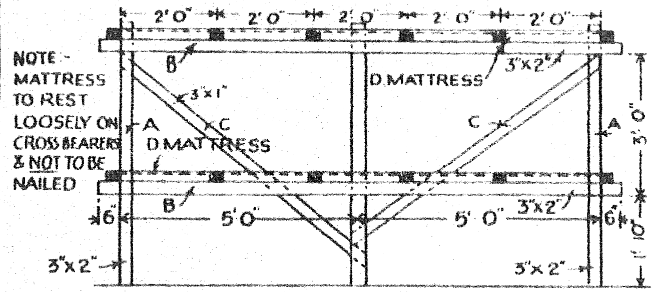
QUANTITIES IN ONE SINGLE DOOR 2'-6" x 6'-8"

Description	Scantling		Nett
Top middle & bottom rails	7" x 1¼"	Feet Run	7½
Styles	3" x 1¼"	" "	13½
Braces	4" x 1¼"	" "	7
Strip	2" x ¼"	" "	15
Boarding T&G	4" x 1"	" "	40
Butts W.I. 3"	–	No of Pairs	1
Latch Norfolk lock & furniture	–	No	1
Zinc flashing 8" wide	–	Feet Run	3
Wire nails 2"	–	LBS	2

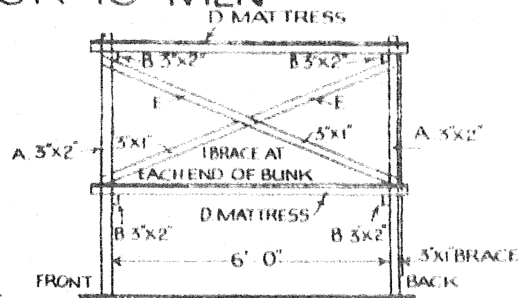
QUANTITIES IN ONE WOOD WINDOW (NETT)

Description	Scantling		
Frame	3" x 3"	Feet Run	21'-0"
Sash	2½" x 1½"	" "	26'-0"
Sill	6" x 3"	" "	3'-10"
Sill fillet	1½" x 1"	" "	3'-10"
Glazing bar	1¾" x 1"	" "	14'-6"
Top filling	5" x 2"	" "	2'-0"
" "	5" x 1"	" "	7'-6"
Clamps with woodscrews	–	No Reqd	4
Fanlight butts	–	"	2
Hopper cheeks	–	"	2
Panes 4th quality 15oz sheet glass	–	"	3
Nails putty etc as required, & one fanlight catch			

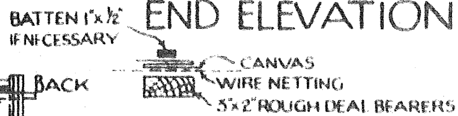
DOUBLE BUNK FOR 10 MEN



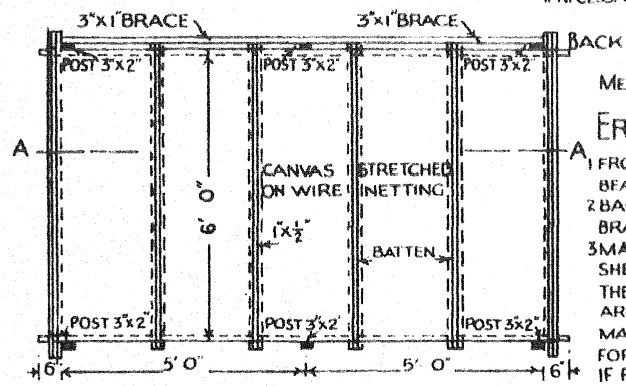
SECTION A-A.



END ELEVATION



METHOD OF FOLDING & SECURING CANVAS ALONG BEARERS



PLAN

ERECTION NOTES

1 FRONT FRAME MADE UP OF THREE UPRIGHTS (A) & TWO CROSS BEARERS (B) 3"x2" ROUGH SAWN.

2 BACK FRAME SIMILAR BUT BRACED WITH 3"x1" ROUGH SAWN BRACES (C).

3 MATTRESS (D) MADE UP OF WIRE NETTING & CANVAS AS SHEWN IN DETAIL. TWO OF THESE ARE REQUIRED PER BUNK. THEY CAN BE ROLLED UP WHEN NOT REQUIRED. THESE BUNKS ARE TRANSPORTED IN THREE PARTS - VIZ (1), (2) & (3) (3) IS MADE UP BY ROLLING THE TWO MATTRESS & BRACES FOR END (E) TOGETHER.

IF REQUIRED THE FLOOR SPACE UNDER BUNK CAN ALSO BE USED AS A SLEEPING SPACE

SCALE

INCHES 12 9 6 3 0 1 2 3 4 5 6 7 8 9 FEET

PLATE 26.

PLATE 27.

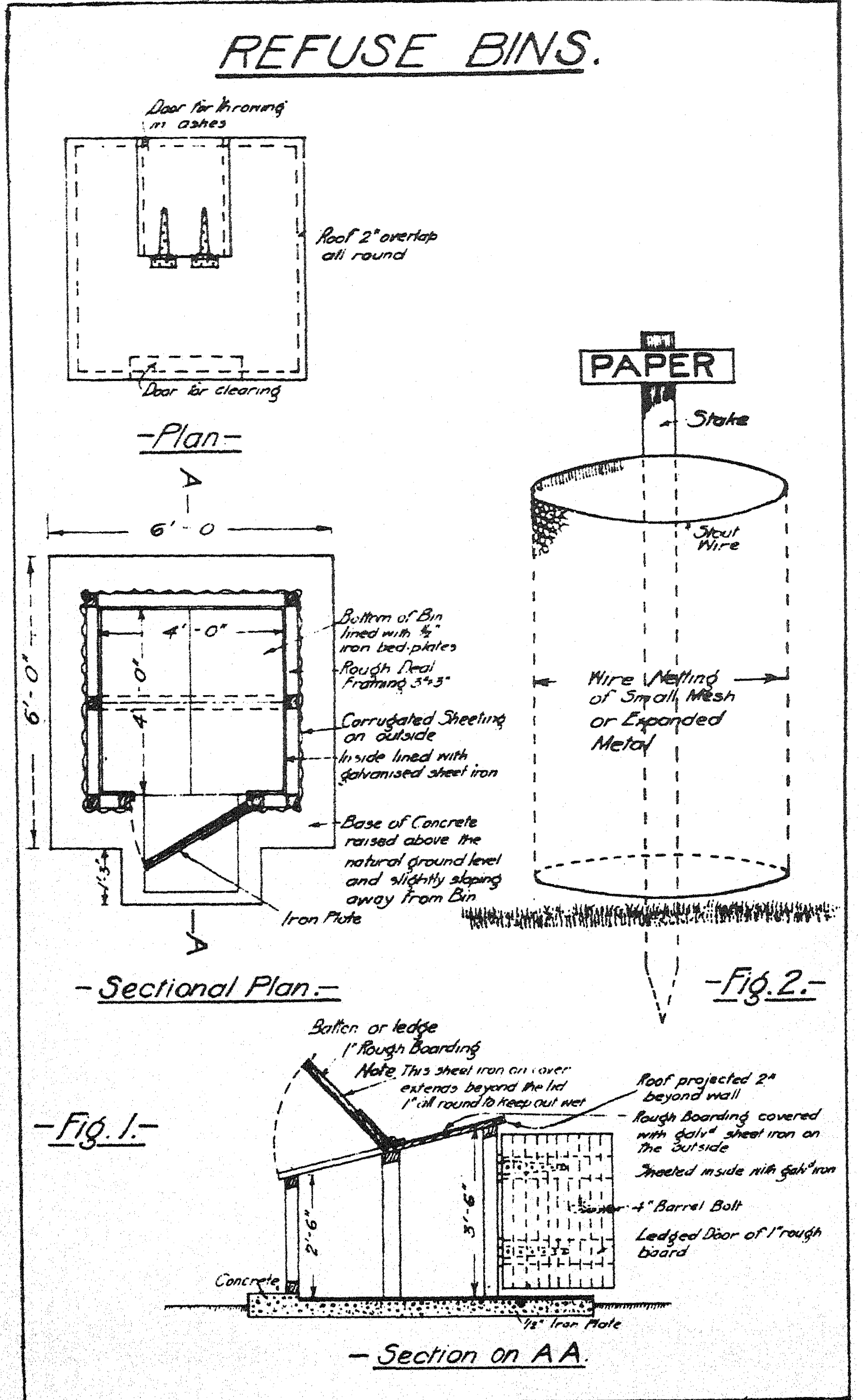
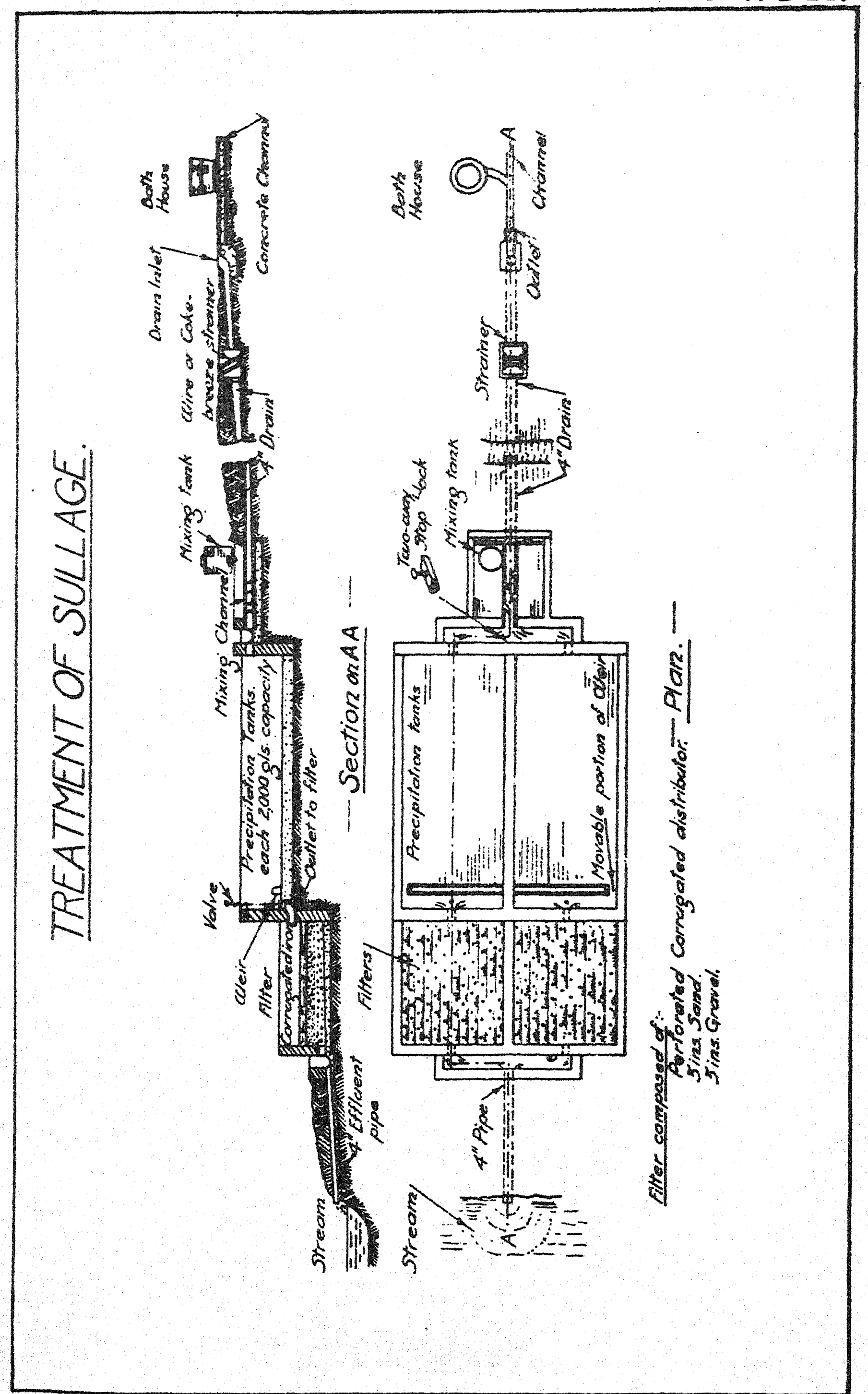


PLATE 28.



FIXING CORRUGATED IRON.

Fig. 1

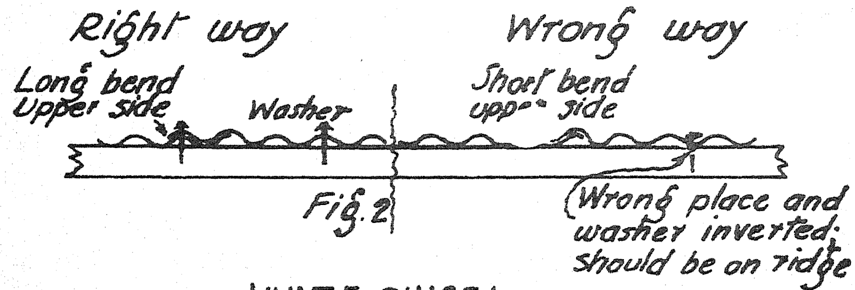


Fig. 2

KNIFE CHISEL

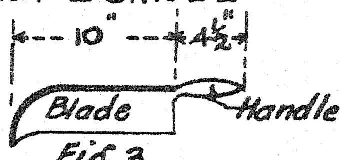
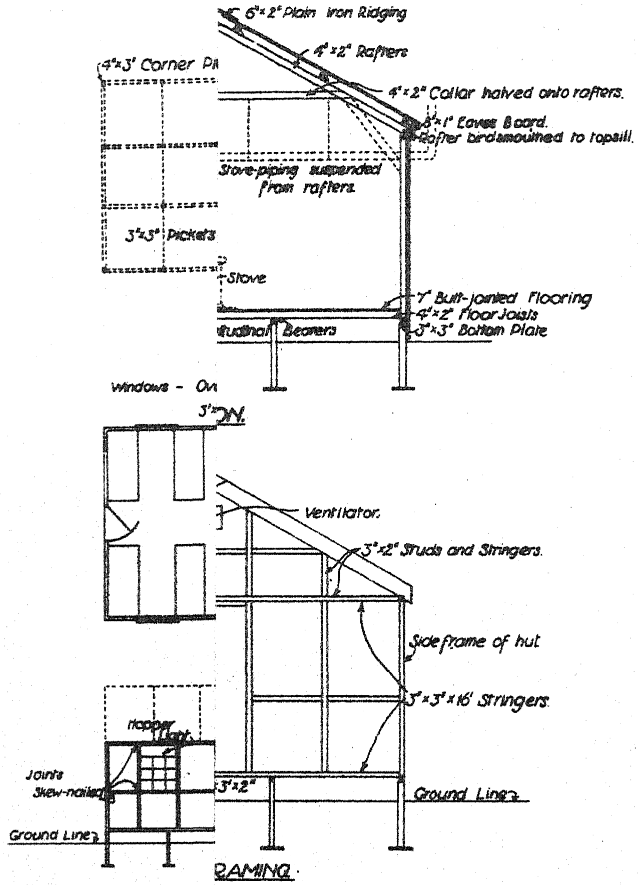
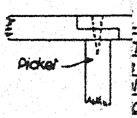


Fig. 3.





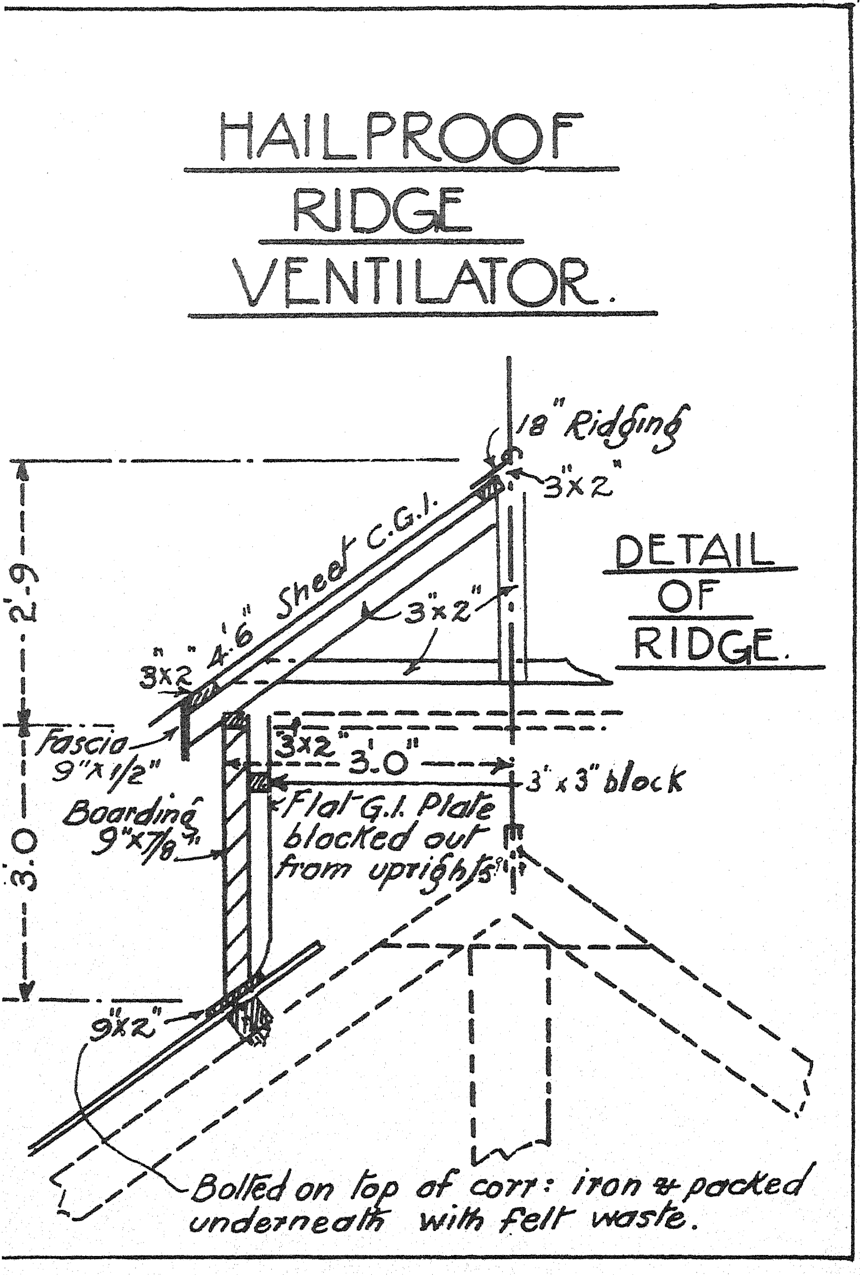
Halved Joint in

TERIALS	QUANTITY.
(with hopper) 4'x3'	12.
ted Sheeting 9'	160.
on Ridging 6'	11.
vith tray.	1.
oing	18 ft. run.
- Elbows	2.
ed Screws & Washers	1500.
6" = 8lbs. 5" = 10lbs	
4" = 30lbs. 2½" - 45 lbs.	

Inches 12 0 1 2

he above quantities
in screws, nails, etc.

Inches 12 6 0


HAILPROOF
RIDGE
VENTILATOR.
18" Ridging
3"x2"
4'6" Sheet C.G.I.
DETAIL
OF
RIDGE.
3"x2"
3"x2"
2'-9
Fascia 9"x1/2"
3"x2"
3'-0"
3"x3" block
Boarding 9"x7/8"
Flat G.I. Plate blocked out from uprights
3'-0
9"x2"
Bolted on top of corr: iron & packed underneath with felt waste.

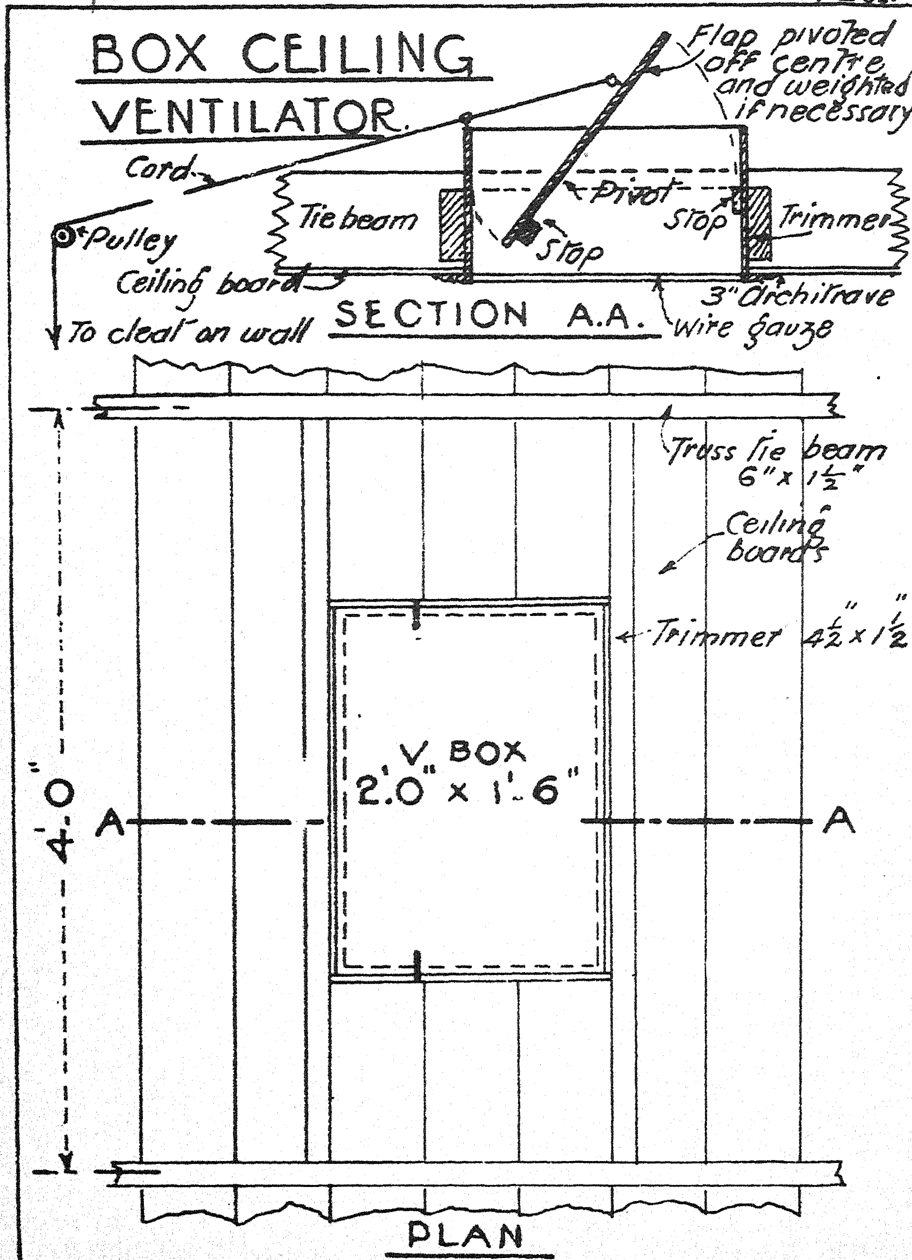

BOX CEILING
VENTILATOR.
Flap pivoted off centre and weighted if necessary
Cord
Pivot
Tie beam
Stop
Trimmer
Pulley
Stop
Ceiling board
3" Architrave
Wire gauze
To cleat on wall
SECTION A.A.
Truss tie beam 6" x 1½"
Ceiling boards
Trimmer 4½" x 1½"
V. BOX
2'.0" x 1'-6"
4'.0"
A
A
PLAN

Plate 33.

FLUE-PIPES THROUGH ROOFS & SIDES AND FLOOR TRAY FOR STOVES.

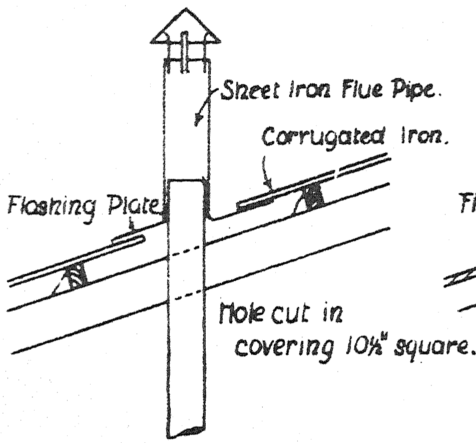


FIG. 1.

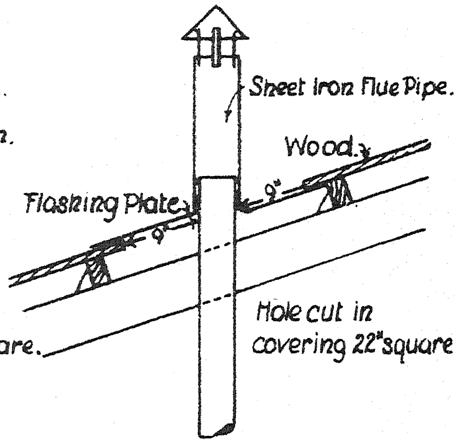
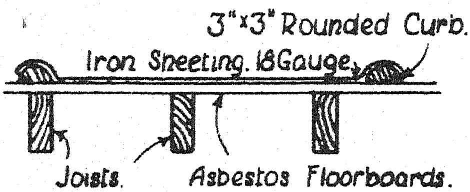
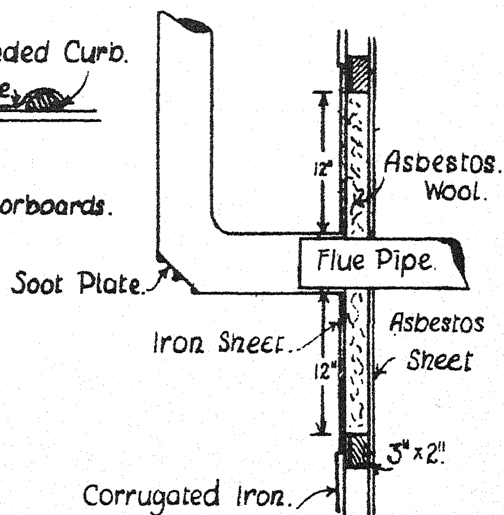


FIG. 2.



Tray to extend 12" in every direction beyond the stove.

FIG. 3.



Alternative Method - By passing fluepipe through breeze block

FIG. 4.

Plate 34.

BRICK FIREPLACES AND CONCRETE FLOORS.

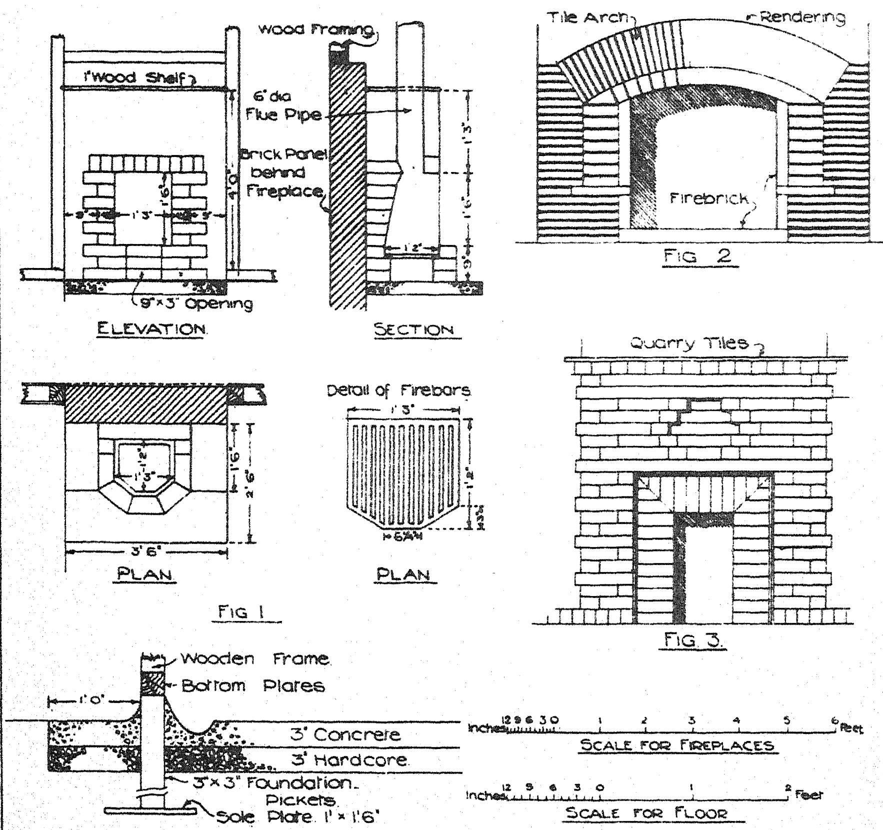
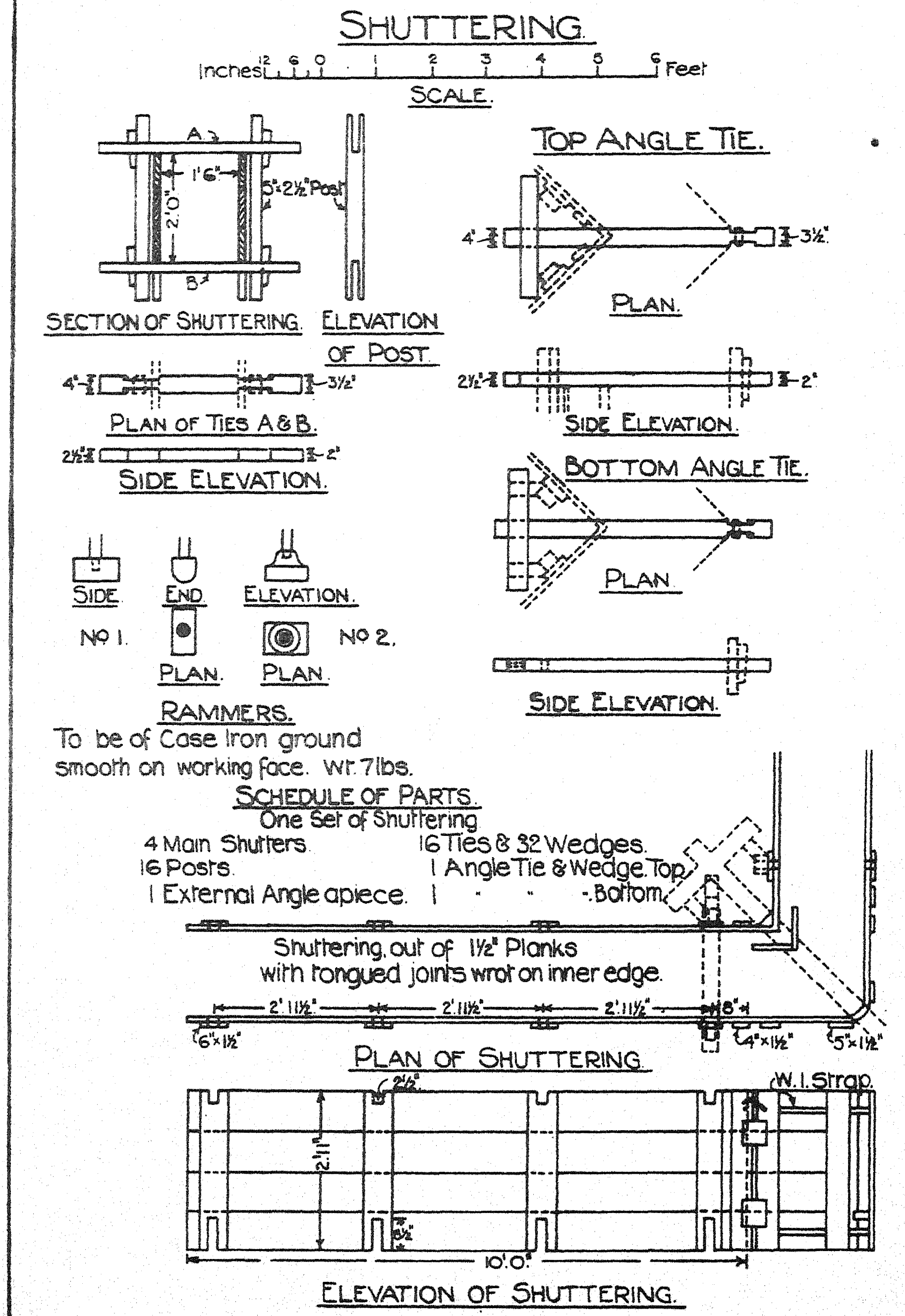
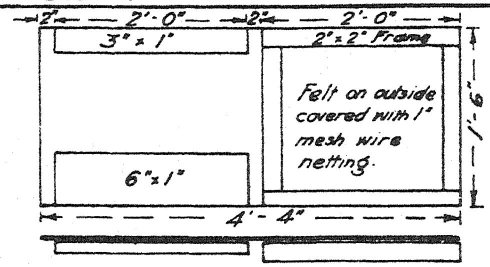


FIG. 4. CONCRETE FLOOR DETAIL.

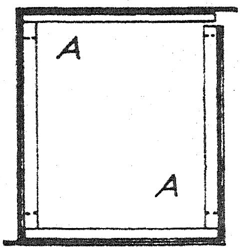
PISÉ-DE-TERRE CONSTRUCTION.



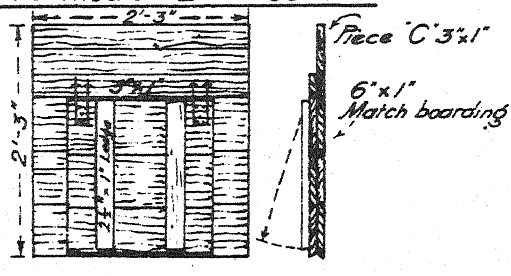
SINGLE SEAT PORTABLE LATRINE.



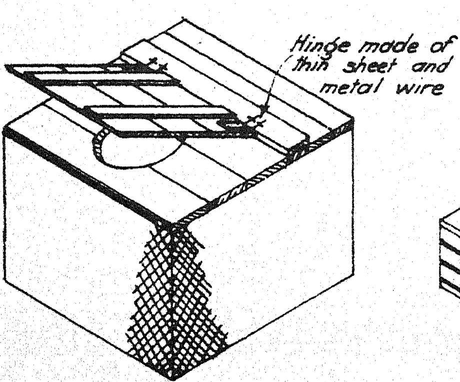
Side & Front Section "A"

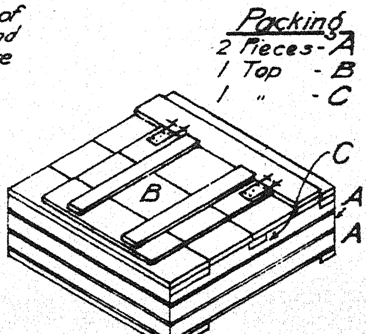


Box Formed of 2 "A" Sections

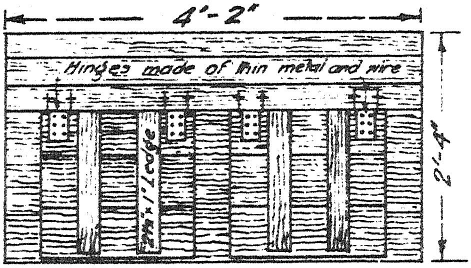


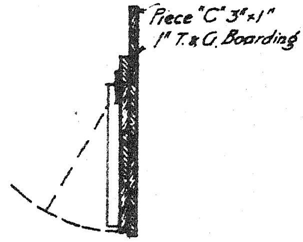
Top "B"



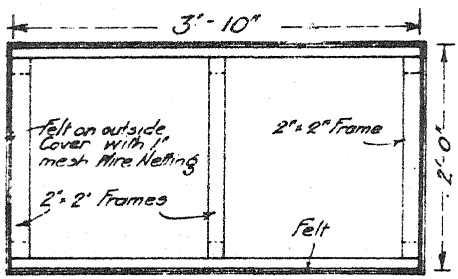


DOUBLE SEAT PORTABLE LATRINE.

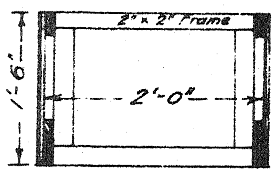




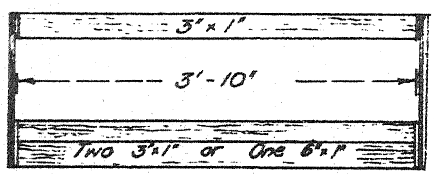
—Top View of Seat.—



—Plan with Top Removed.—

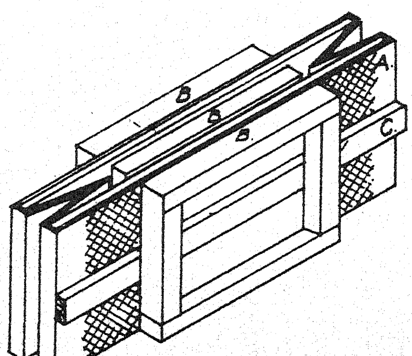


—Cross Section.—



—Inside of Back or Front.—
(which are the same.)

Note.- Front and Back "A" are made in one piece and close up concertina fashion for packing.



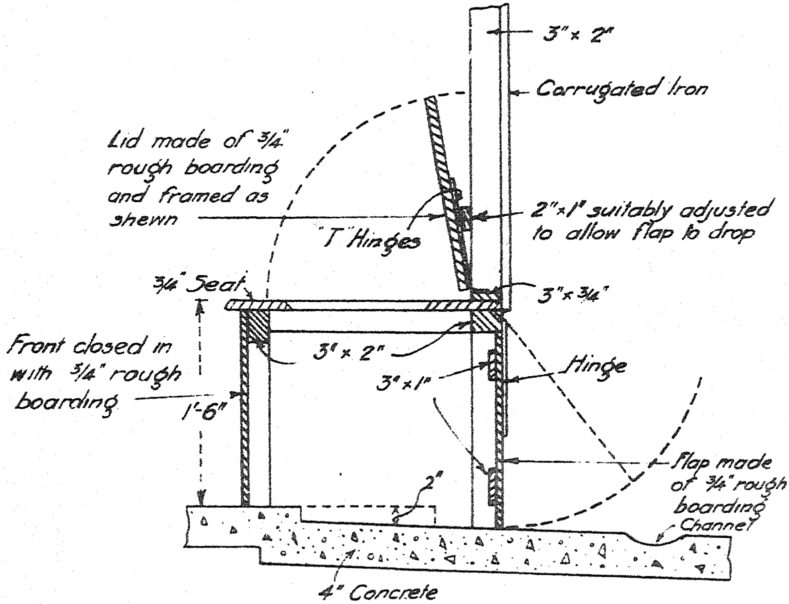
The Felt and Wire will cove in sufficiently to pack C as shewn

—Packing.—

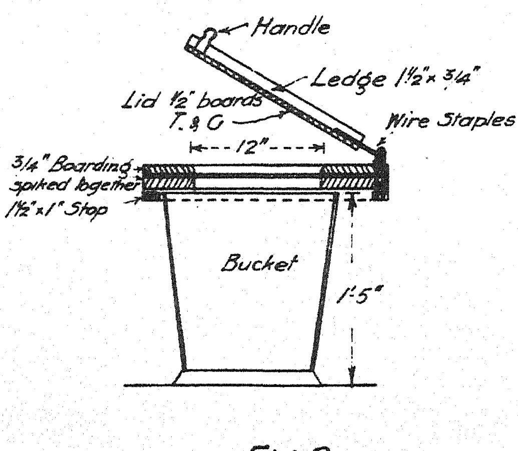
1 - Piece. A
3 - " B
1 - " C
} in 1 Bundle.

1 - Top sent separate

PAIL LATRINES.

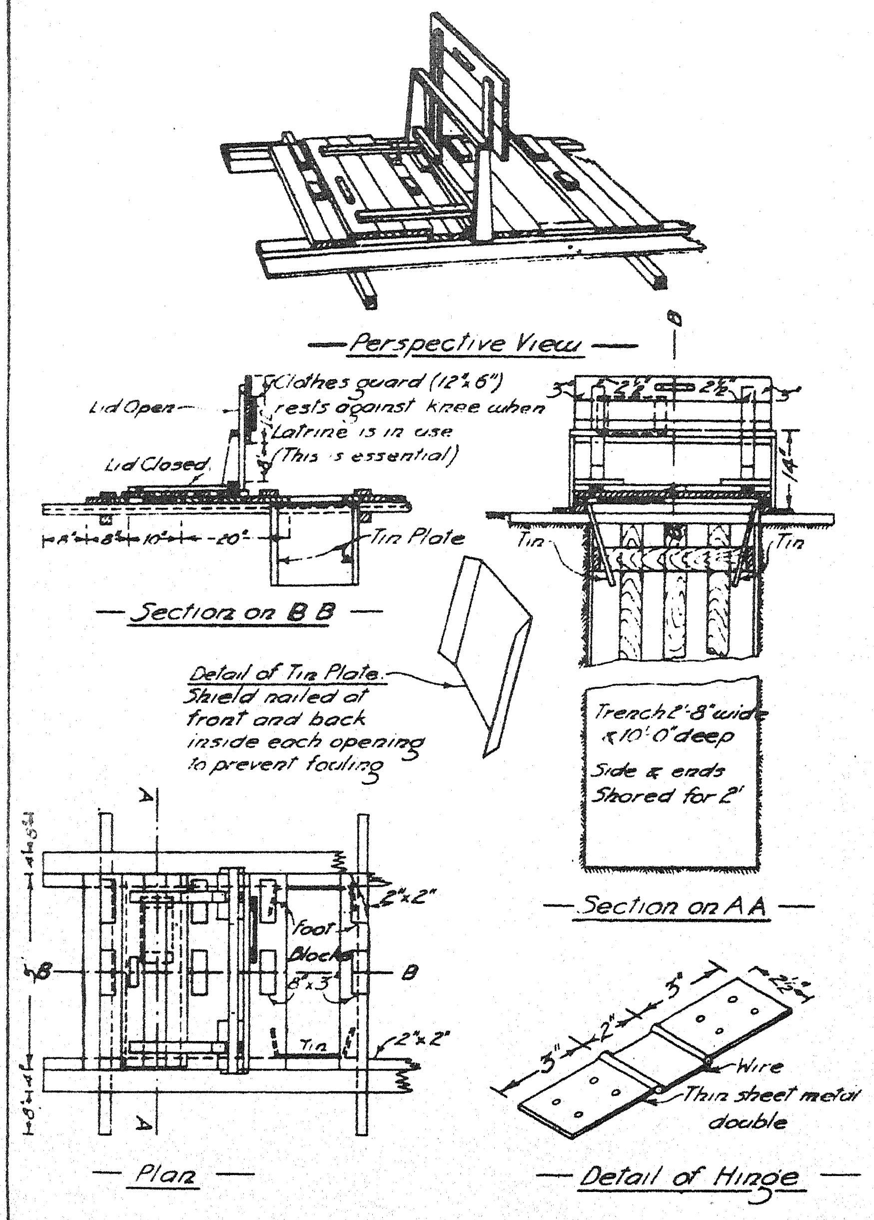


-Fig. 1.-



-Fig. 2.-

SQUATTER LATRINE.



URINALS.

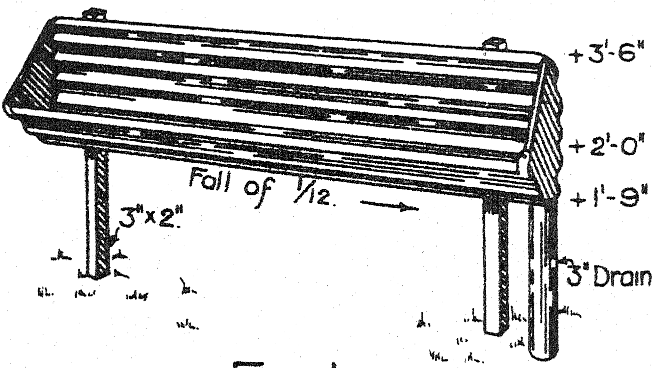


Fig. 1.

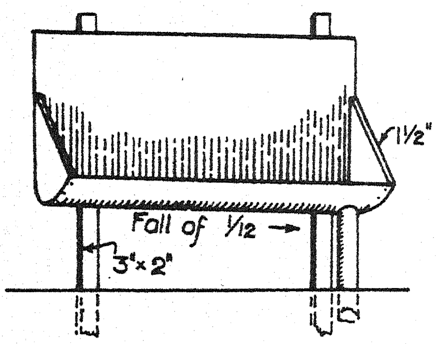


Fig. 2.

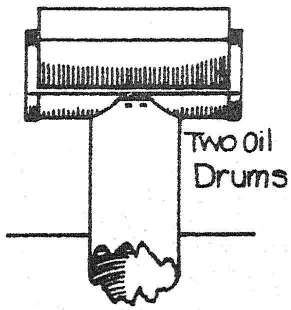


Fig. 3.

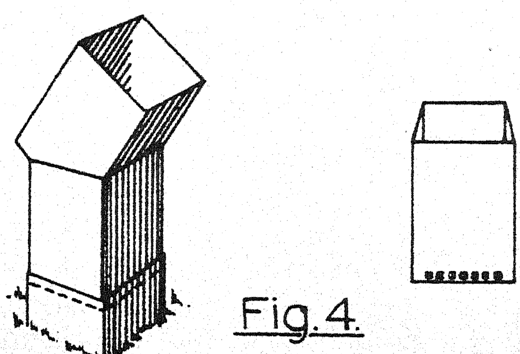
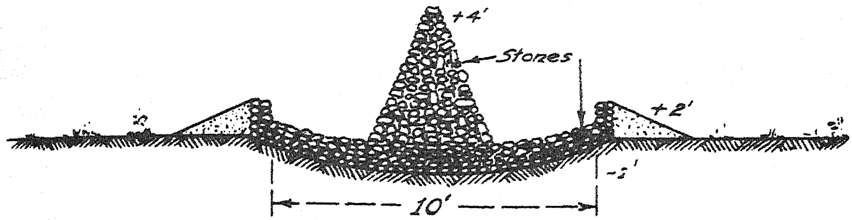
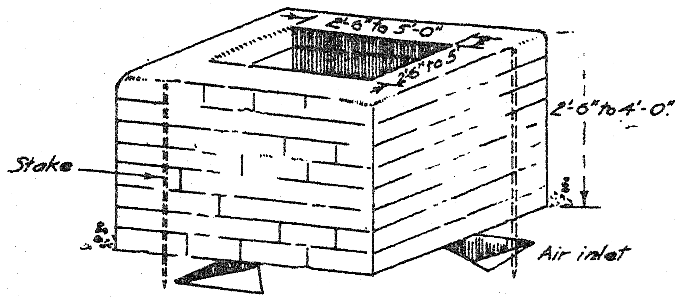


Fig. 4.

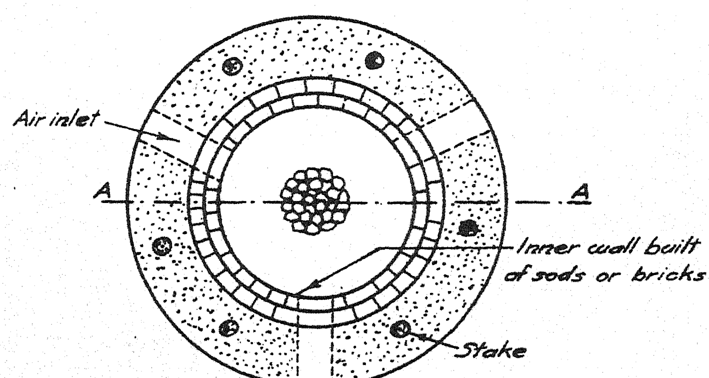
OPEN INCINERATORS



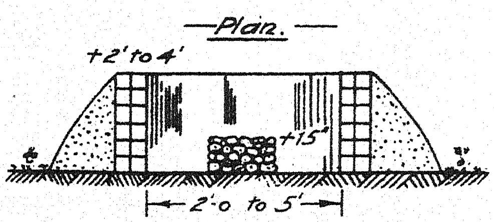
— Fig. 1. —



— Fig. 2. —



— Plan. —



— Section on AA —

— Fig. 3. —

CLOSED INCINERATORS.

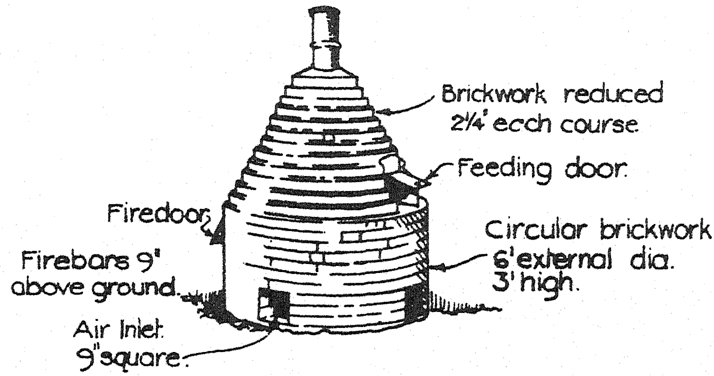


Fig. 1.

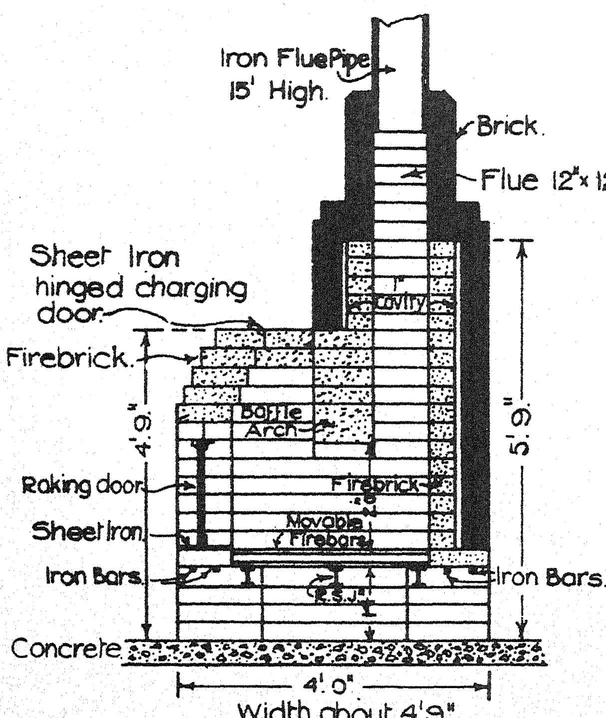
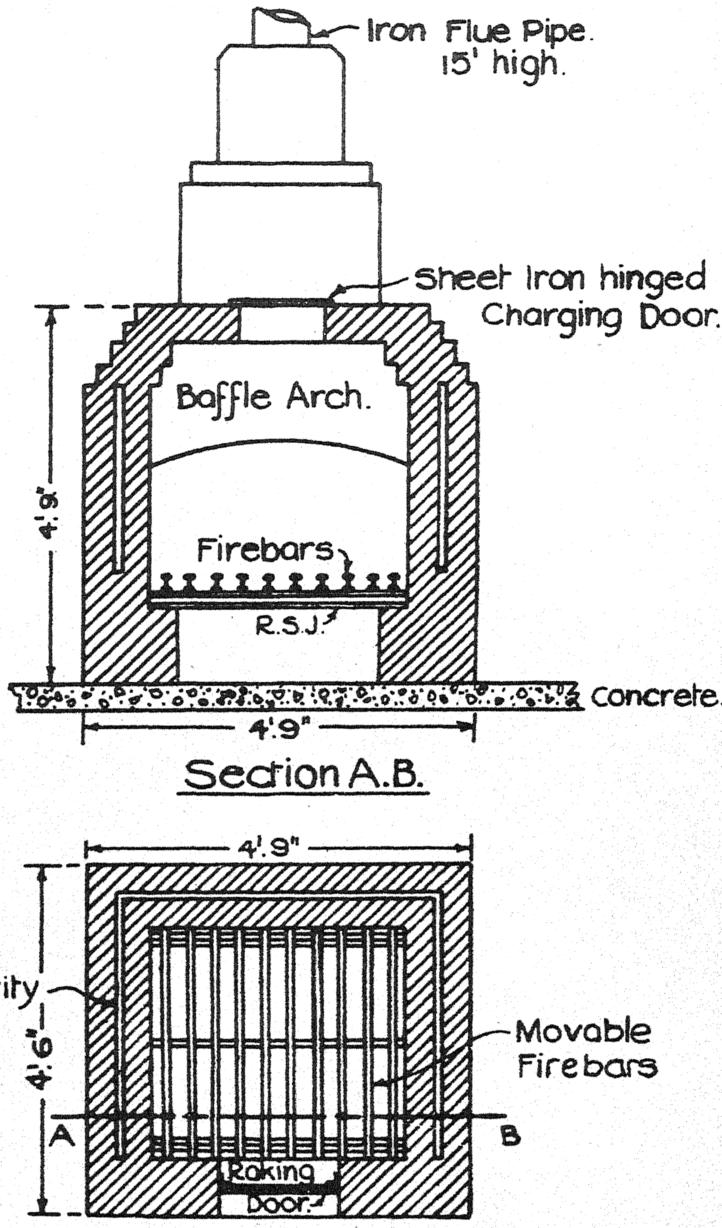


Fig. 2.

INCINERATOR WITH BAFFLE WALL.

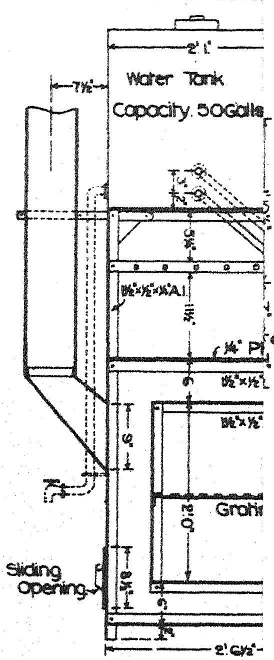


Section A.B.

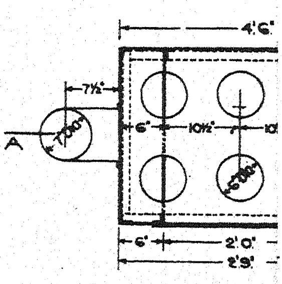
Plan.

IMP VES.

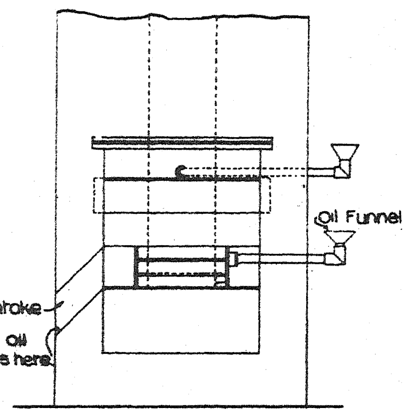
FIG.1 FUEL OIL C



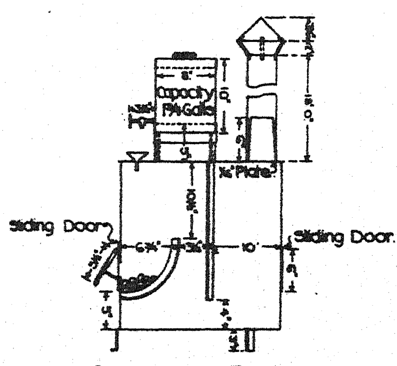
SECTIO



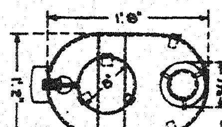
PLAN.(TANKS RE



CROSS SECTION.



SECTIONAL ELEVATION



PLAN.

FIG.4 FUEL OIL HEATING STOVE.
(SMALL SIZE)

IMPROVISED OIL COO RS AND STOVES.

Inches 12 9 6 3 0 1 2 3 4 5 6 7 8 Feet

SCAL ALL FIGURES

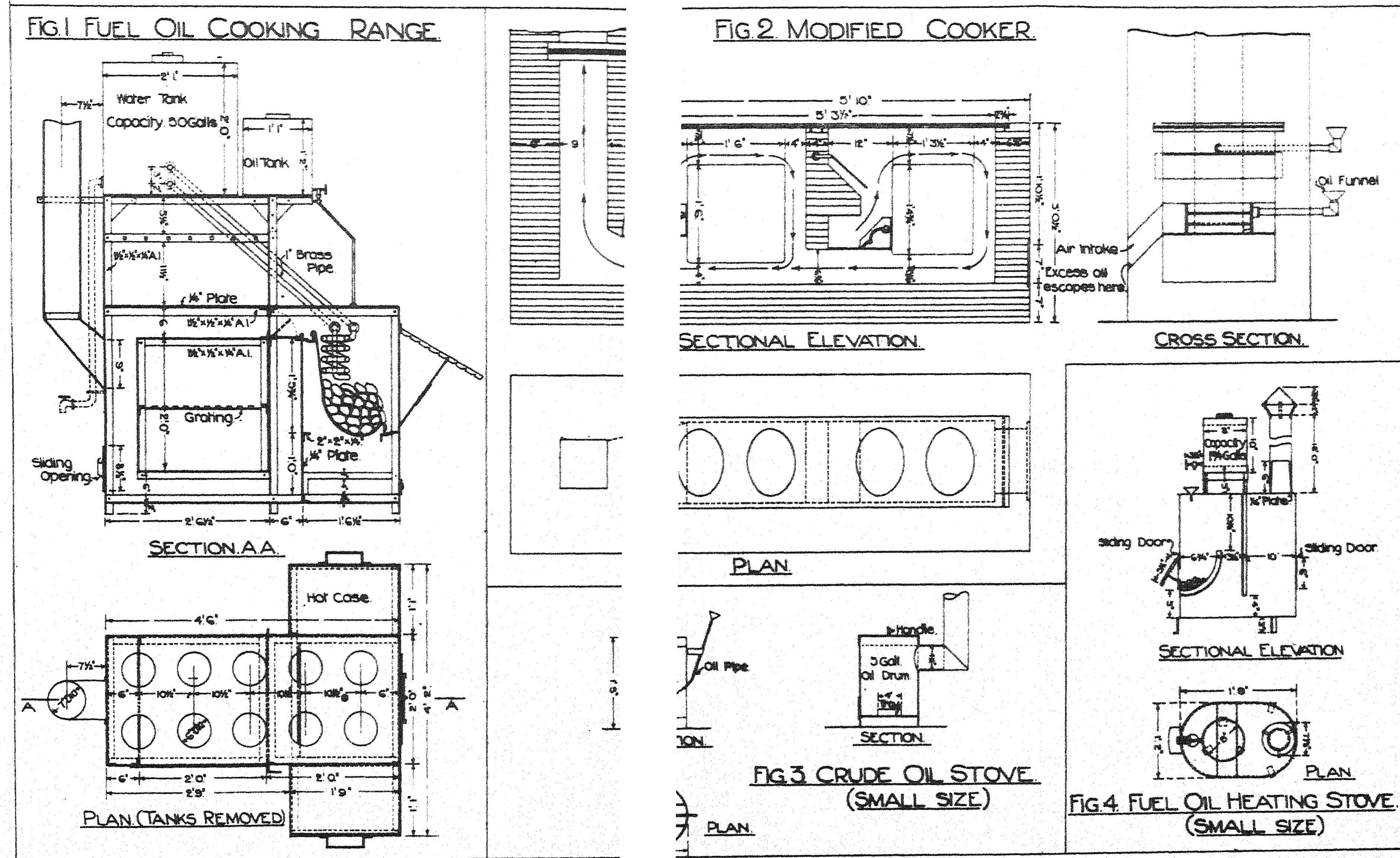


FIG. 1 FUEL OIL COOKING RANGE

SECTION. A.A.

PLAN. (TANKS REMOVED)

FIG. 2 MODIFIED COOKER

SECTIONAL ELEVATION.

CROSS SECTION.

PLAN.

FIG. 3 CRUDE OIL STOVE (SMALL SIZE)

SECTION.

PLAN.

FIG. 4 FUEL OIL HEATING STOVE. (SMALL SIZE)

SECTIONAL ELEVATION

PLAN.

ABLUTION BENCHES & BASINS.

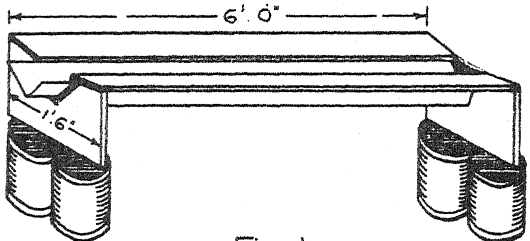


Fig. 1.

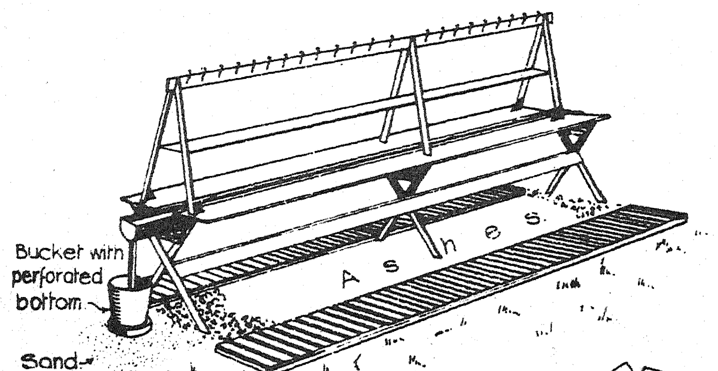


Fig. 2.

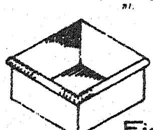


Fig. 3.

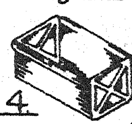
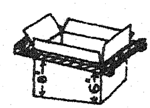
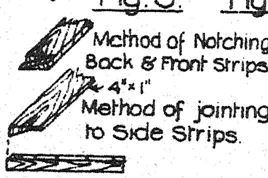


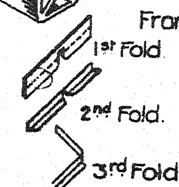
Fig. 4.



Shewing how Corners of Tin are cut and sides folded over Framework. (Secured by nails on underedge)



Details of Wooden Framework.



Details of Soap Tray.

Completed Wash Basin.

Fig. 5.

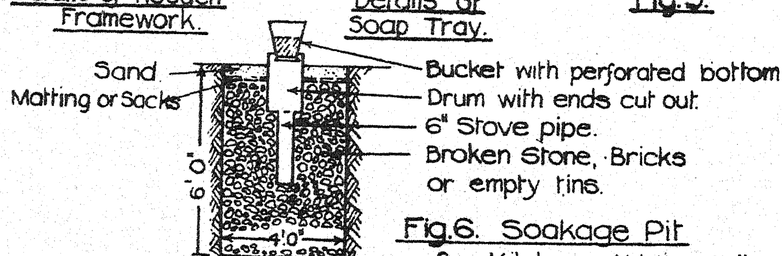


Fig. 6. Soakage Pit for Kitchen & Ablution Sullage.

TYPICAL ARRANGEMENT FOR A CLEANSING STATION.

FIG. 1A.

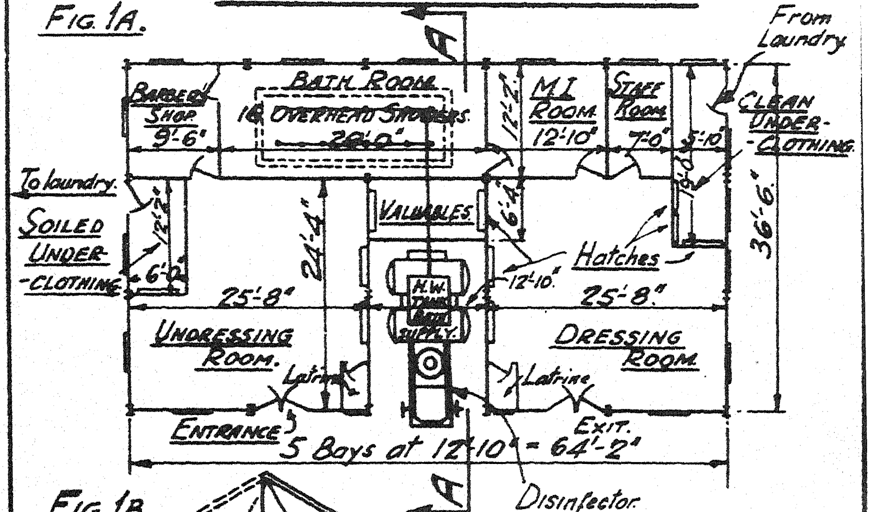
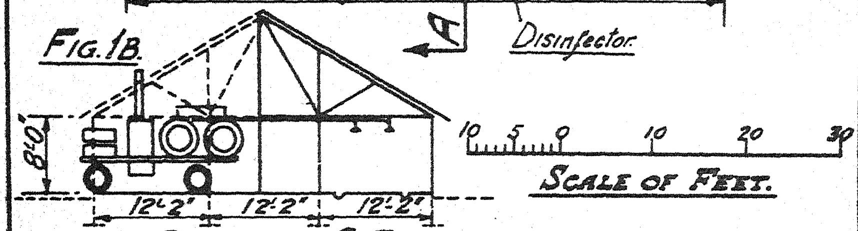
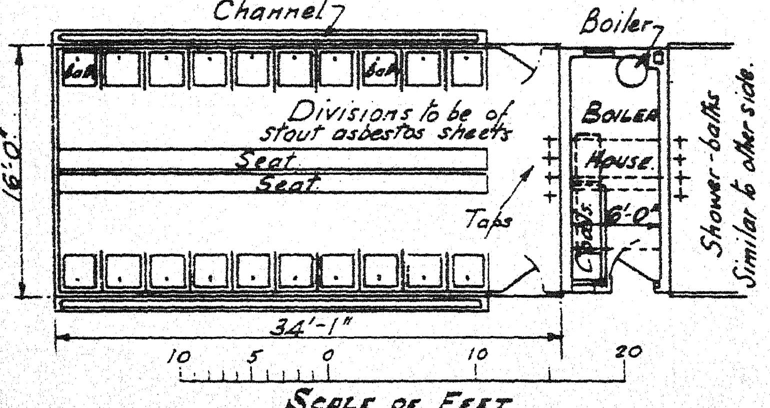


FIG. 1B.

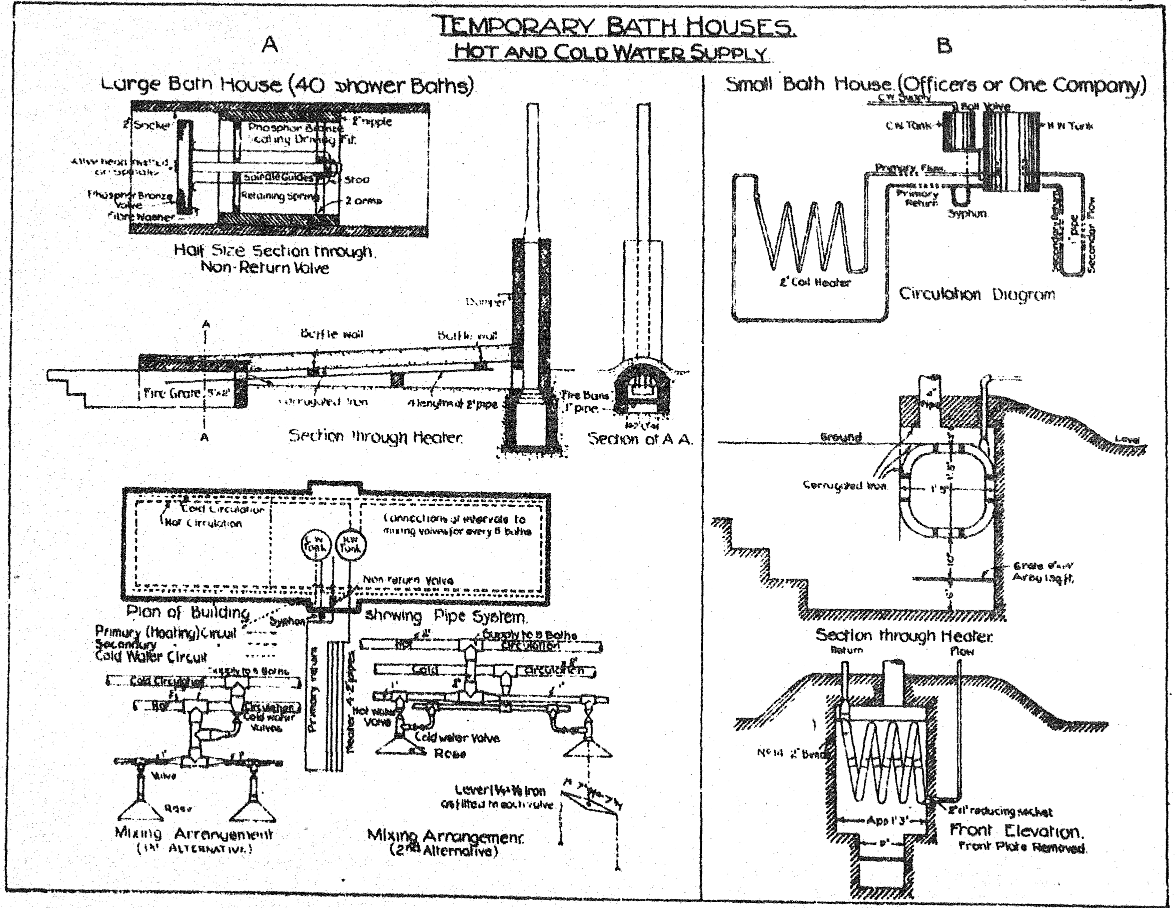


SECTION A.A.

FIG. 2. BATH HOUSE. 16' SPAN. WOOD.



Temporary Bath Houses.
Hot and Cold Water Supply.



GREASE TRAPS.

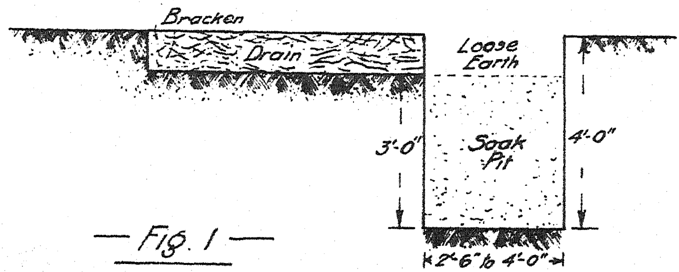


Fig. 1

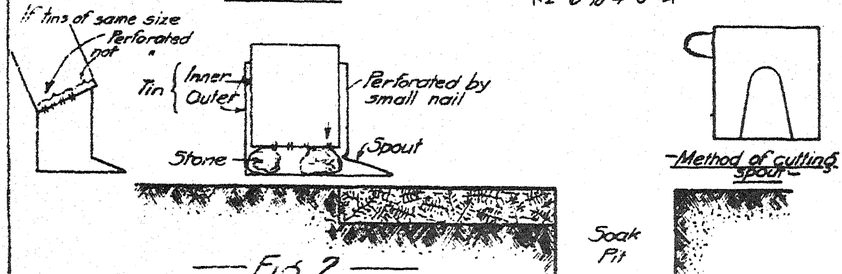


Fig. 2

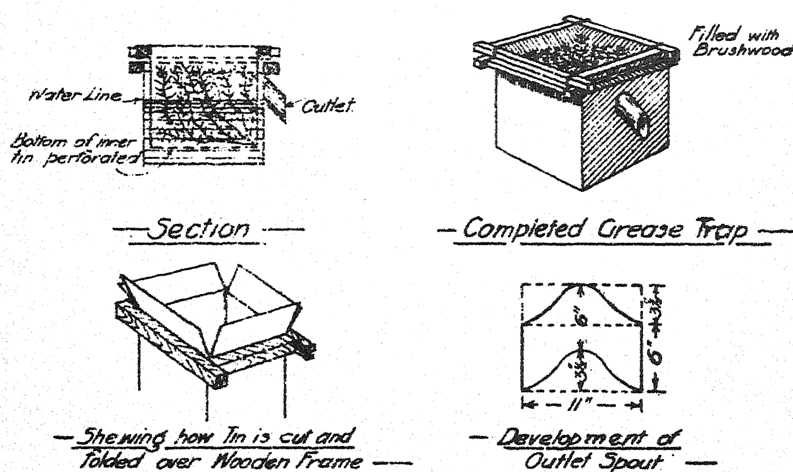


Fig. 3.

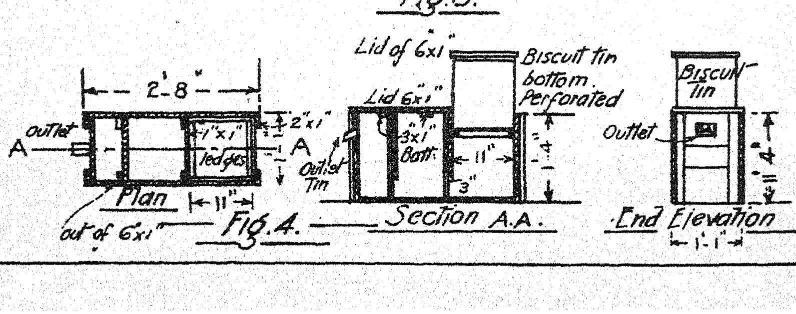
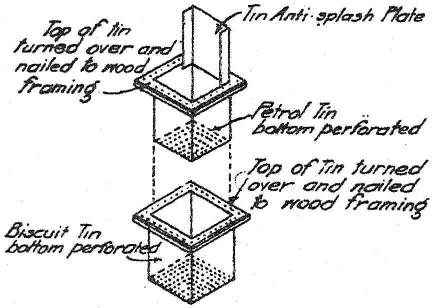
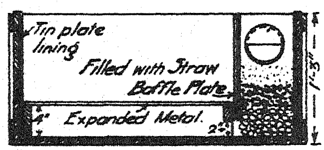


Fig. 4.

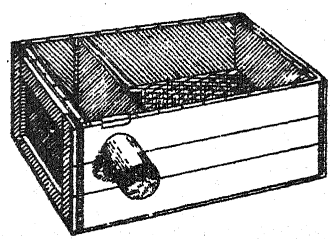
SOAP TRAPS.



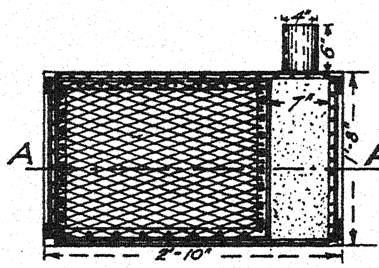
— Fig. 1 —



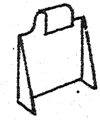
— Section on AA —



— Perspective View —

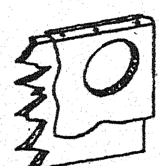


— Plan —

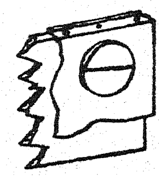


— Detail of Scum Plate —

— Tin Canister with lower half of Bottom cut away —



— Tin Plate Lining Notched and Turned in —

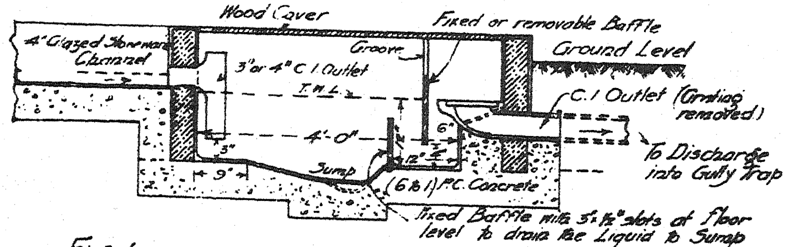


— Canister inserted from inside, and joint made good by soldering around rim —

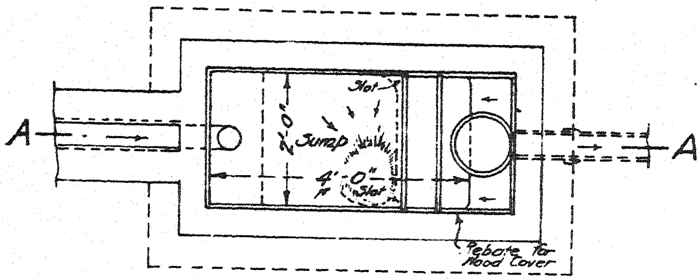
— Fig. 2 —

— Details of Outlet —

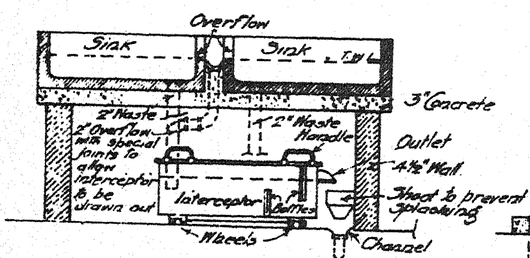
GREASE INTERCEPTORS



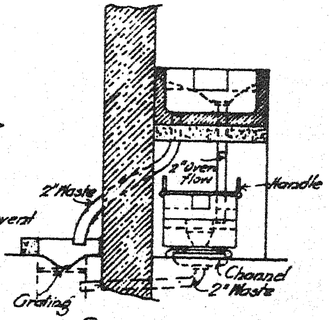
-Fig.1.- -Section on AA-



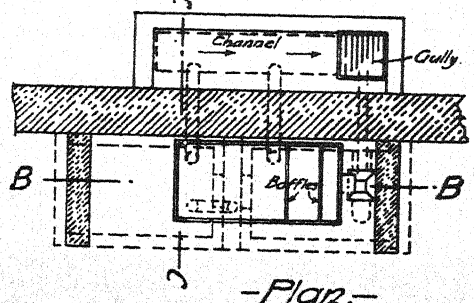
-Plan.-



-Section on BB-

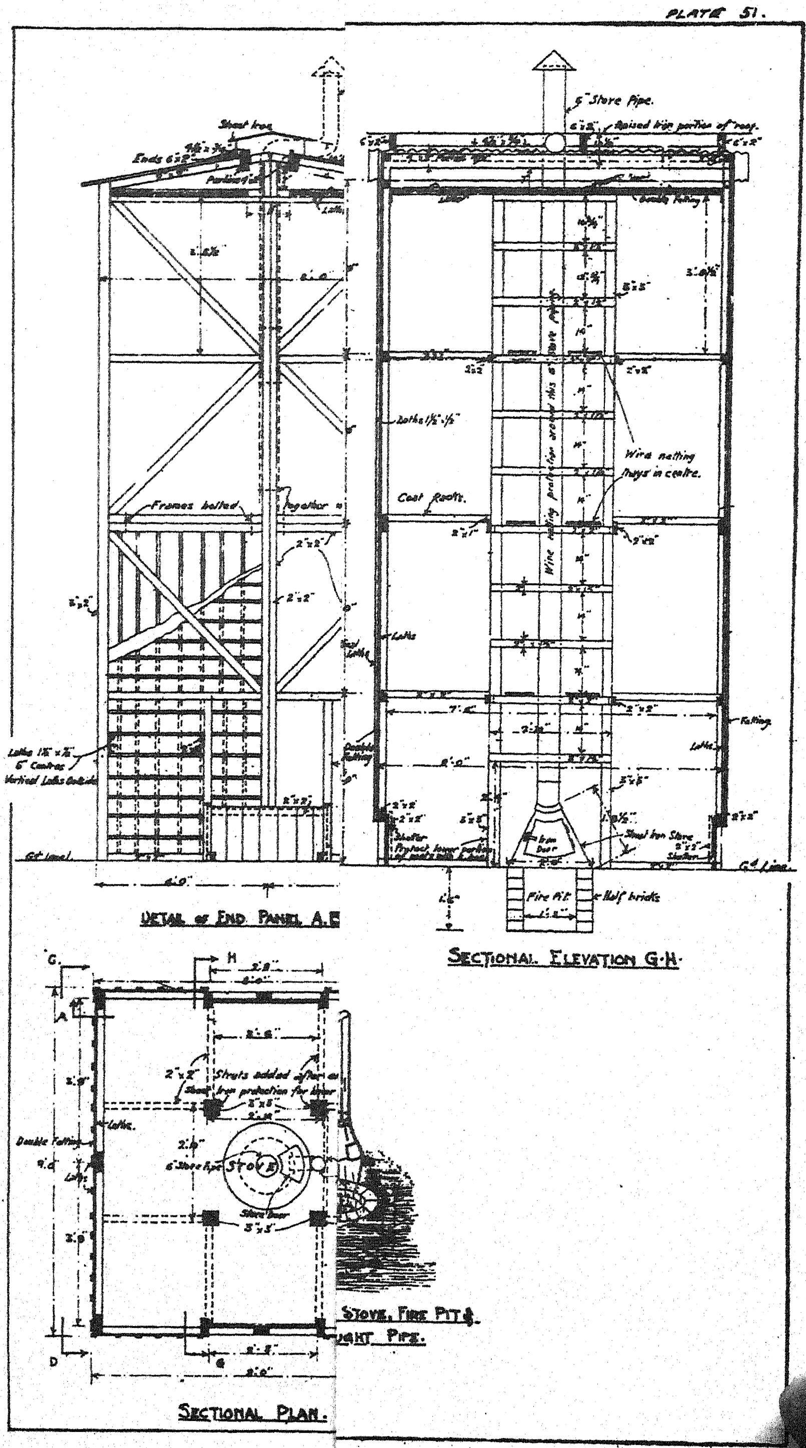


-Section on CC-



-Fig.2.-

-Plan.-

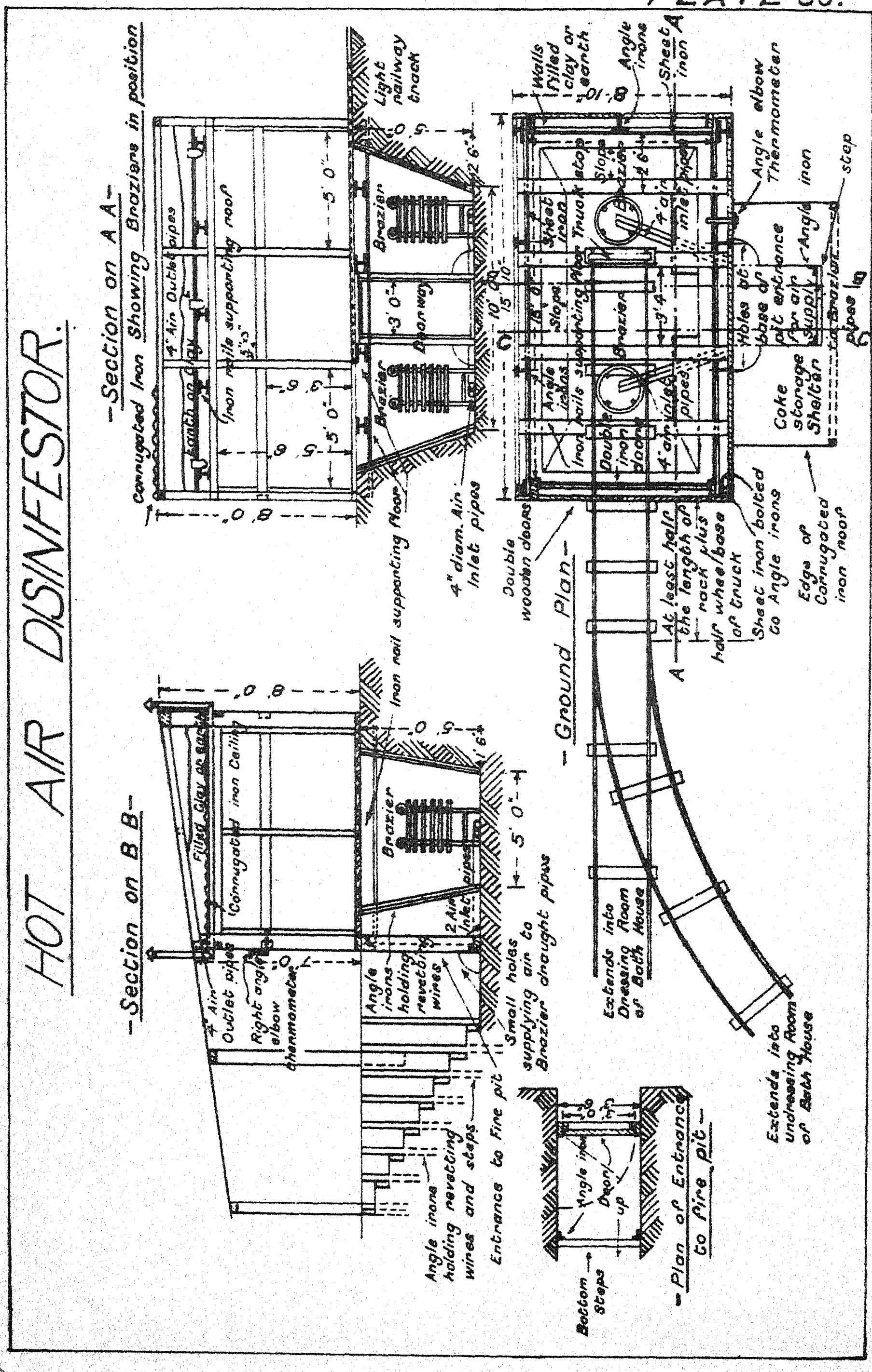


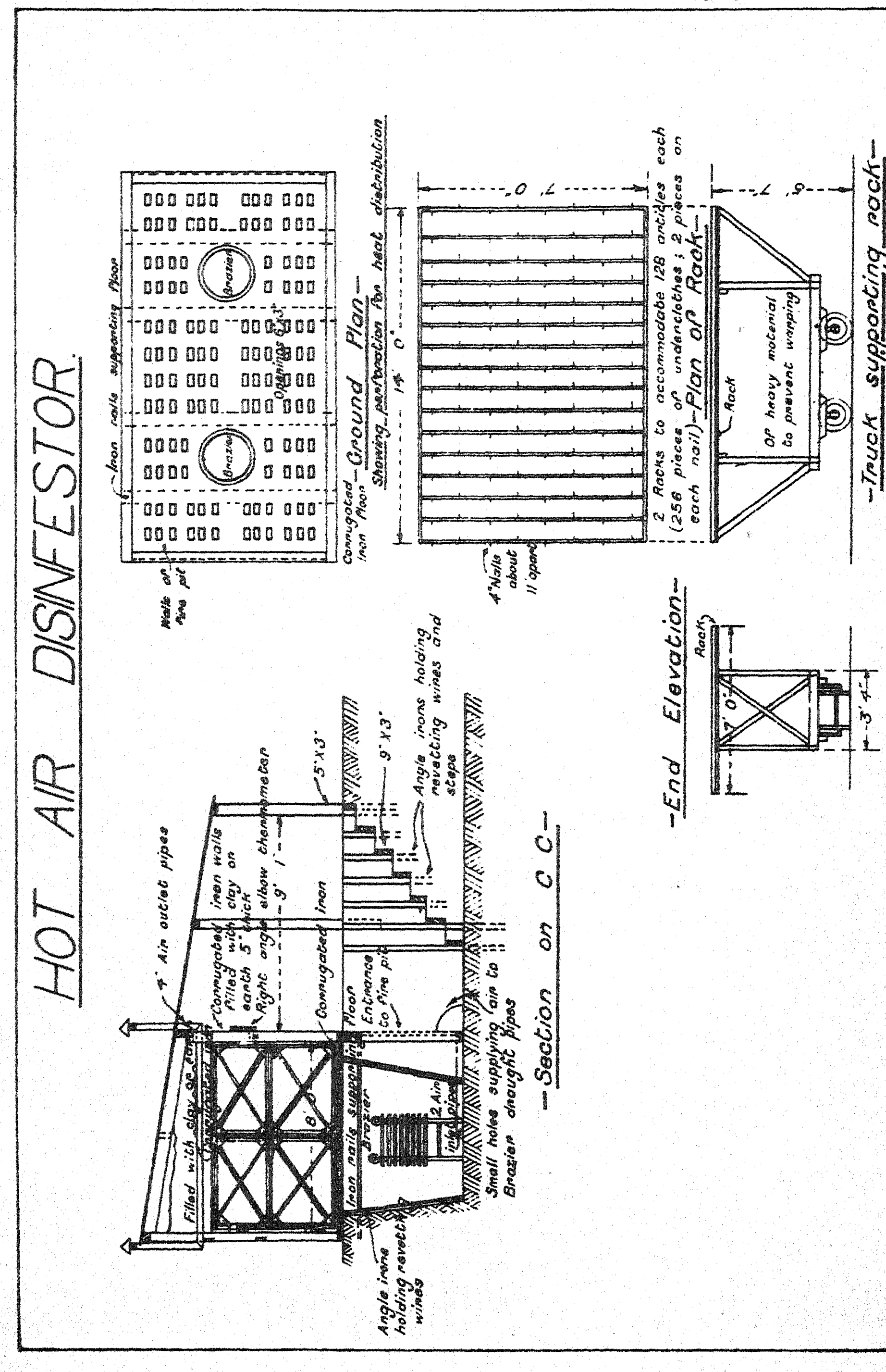
DETAIL OF END PANEL A.B

SECTIONAL ELEVATION G-H.

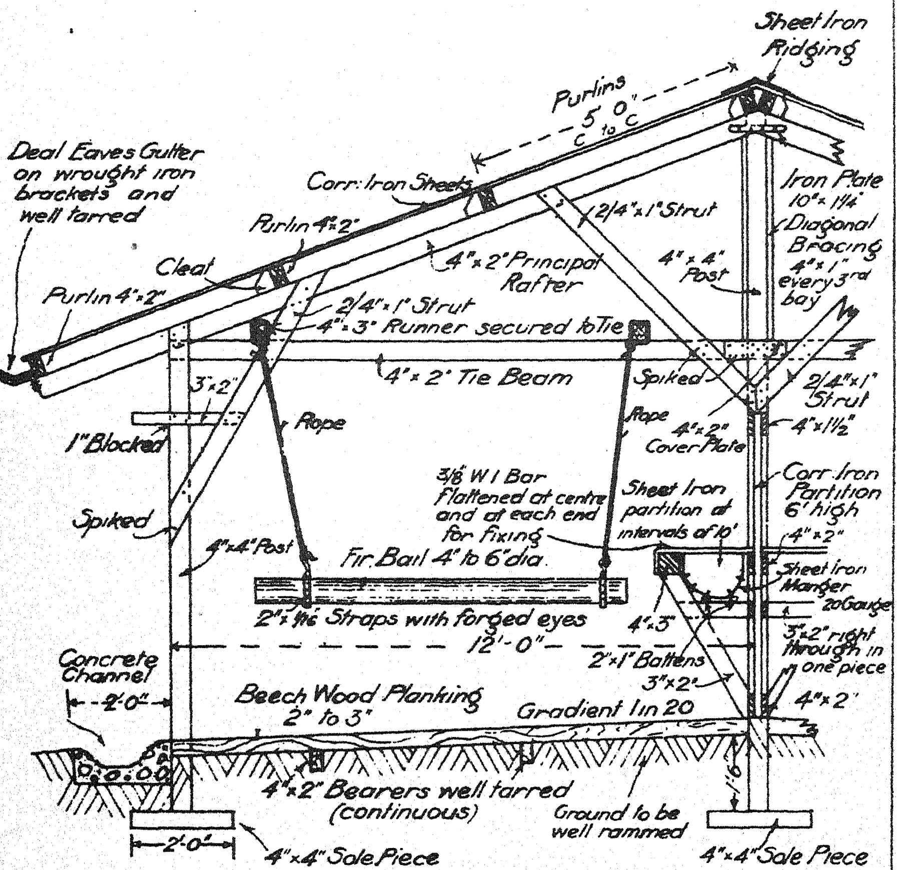
STOVE, FIRE PIT & DRAUGHT PIPE.

SECTIONAL PLAN.


HOT AIR DISINFESTOR.
-Section on A A-
Corrugated Iron Showing Braziers in position
-Section on B B-
-Ground Plan-
-Plan of Entrance to fire pit-
Brazier
Light railway track
Coke storage Shelter
Double wooden doors
Extends into Dressing Room of Bath House
Extends into undressing Room of Bath House
Entrance to Fire pit
Iron nail supporting floor
4" diam. Air Inlet pipes
Small holes supplying air to Brazier draught pipes
Angle irons holding revetting wires and steps

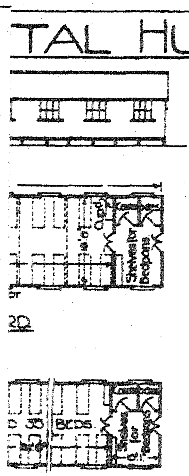

HOT AIR DISINFESTOR.
-Section on C C-
-Ground Plan-
Showing perforation for heat distribution
-Plan of Rack-
-End Elevation-
-Truck supporting rack-
2 Racks to accommodate 128 articles each (256 pieces of underclothes; 2 pieces on each nail)
Of heavy material to prevent warping
4" Air outlet pipes
Filled with clay or earth
Small holes supplying air to Brazier draught pipes
Angle irons holding revetting wires

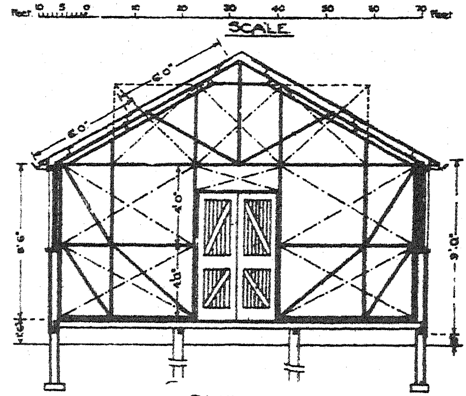
STABLES.



— Section —

TAL HUT (STEEL FRAME.)





SECTION.

SHEWING END FRAME AND INSIDE LINING BOARDS.

D.

QUANTITIES (SINGLE WARD)

DESCRIPTION.		AMOUNT REQUIRED.
INTERNAL DOUBLE DOORS (2)		
Styles and Top Rails.	3" × 1¾"	62 Ft. Run.
Middle Rails.	7" × 1¾"	8 " "
Bottom Rails.	9" × 1¾"	8 " "
Panels 3-ply.	18" wide	22 " "
Linings.	4" × ¾"	35 " "
Stops.	2" × ½"	35 " "
Butts and Screws.		4 Pairs
Rim Locks and Furniture.		2 Nº
INTERNAL SINGLE DOORS (7)		
Frame Top	4" × 2"	21 Feet Run.
Stop.	2" × ½"	112 " "
Rails, Top, Middle and Bottom	6" × ¾"	56 " "
Braces.	4" × ¾"	49 " "
Boarding, T.G. and V Jointed.	6" × ¾"	231 " "
Butts and Screws.		7 Pairs.
Norfolk Latches.		7 Nº
WINDOWS (23)		
Window Framing.	3" × 3"	311 Ft. Run.
" " Top.	3" × 1½"	94 " "
" " "	1½" × 1½"	94 " "
" Sashes.	2½" × 1¾"	598 " "
" Sills.	6" × 3"	73 " "
" " Fillers.	1¼" × 1"	73 " "
" Glazing Bars.	1¾" × 1"	334 " "
Steel Clamps with Wood Screws		92 Nº
Fanlight Butts and Screws.		23 Pairs.
" Catches.		23 Nº
" Hopper Cheeks.		23 Pairs.
Glass Panes.	1'8" × 1'1"	207 Nº
INTERNAL LININGS FOR CEILING, SIDES AND ENDS.		
Compo Boarding.	8'0" × 4'0"	145 Nº
LINING FOR PARTITIONS.		
Compo. Boarding.	8'0" × 4'0"	76 Nº
GUTTERS AND DOWNPIPES.		
Gutter Boards T and G.	4" × 1"	504 Feet Run,
" Ends and Blocks.	4" × 1"	19 " "
" Fascia Boards and Blocks.	7" × 1"	270 " "
" Hoop Iron Straps.	1"	126 " "
Zinc Outlets for Downpipes.		4 Nº
" Downpipes. 2½" dia × 10 G.	7' 6"	4
" " Swan-necks.		0 "
" " Shoes.		0 "
Galv. " Clasps		8 "

NAILS. – 4" - 440 lbs. 2¼" - 160 lbs. 1¼" - 10 lbs. 1¼" for Compo. Board - 40 lbs.

For quantities for Double Ward, double the quantities shewn in above table; deduct quantities for the Duty Room and Scullery annexes, and add the quantities for Duty Room and Scullery Block shewn in the centre of Double Ward.

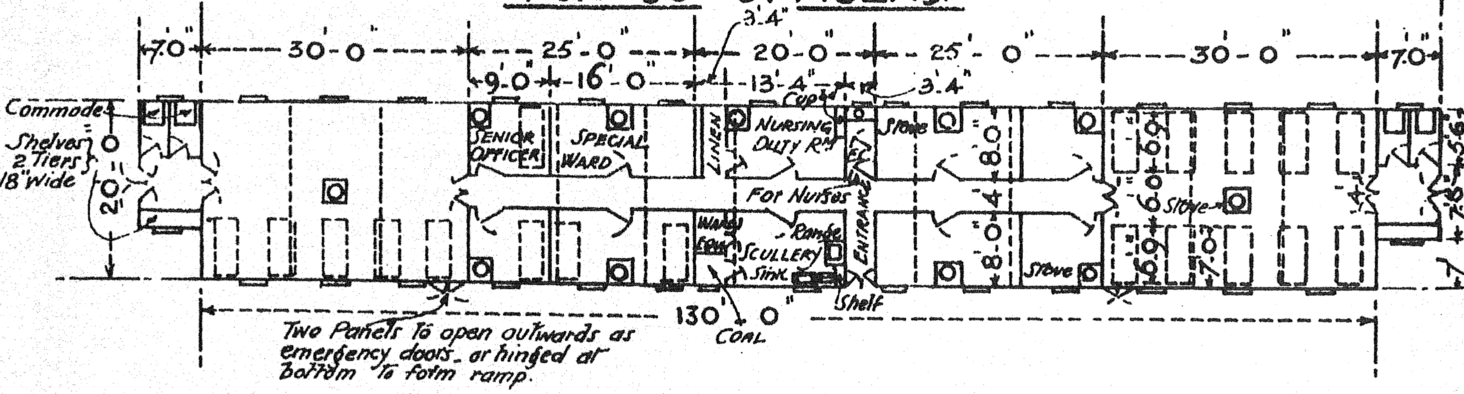
REQUIRED.

91
170
26
100
78
100
700
165
12
100
134
24
560
300
180
78 Ft. Run.
810 " "
570 " "
304 " "
160 " super.
45 " Run.
312 Feet Run
66 " "
20 " "
38 " "
277 " "
732 Feet Run.
84 " "
84 " "
38 " "
24 " "
44 Nº
606 Feet Run.
53 Feet Run.
108 " "
12 " "
12 " "
36 " "
62 " "
12 " "
14 " "
9 Pairs.
3 Nº
6 "

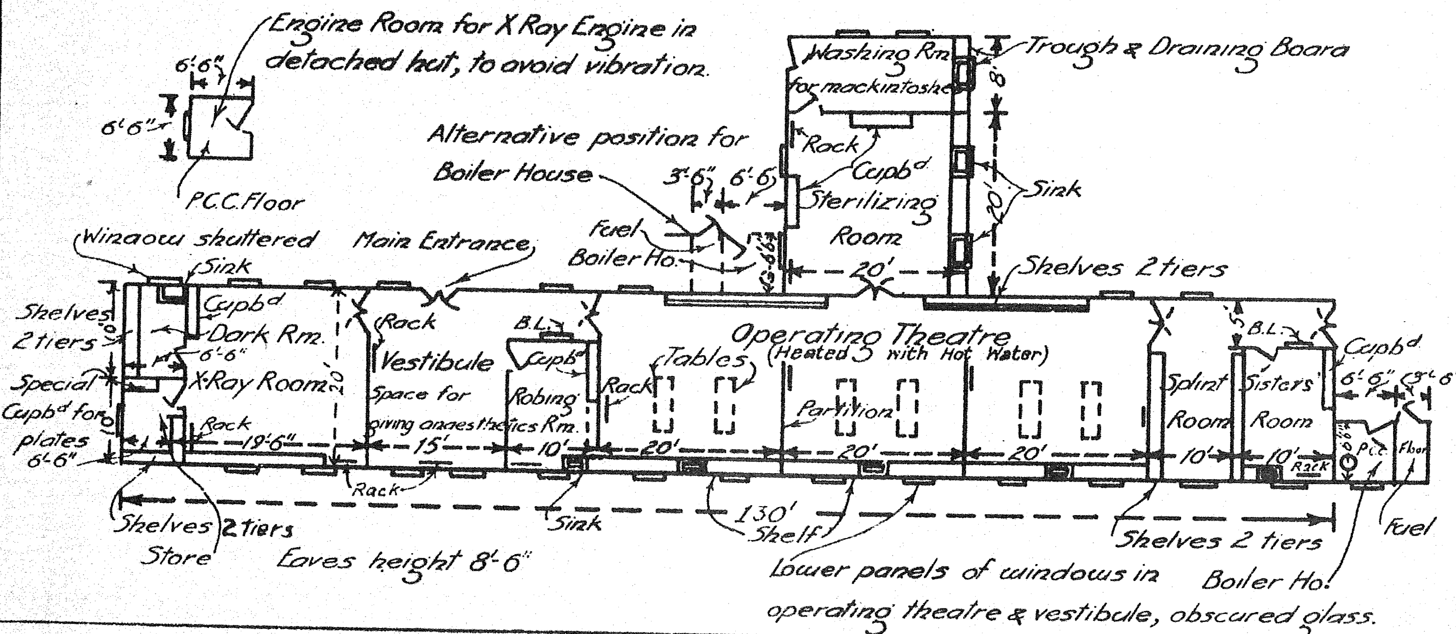
PLATE 57.

OFFICERS' WARD.

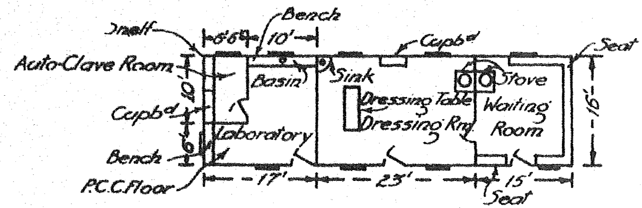
FOR 30 OFFICERS.



OPERATION BLOCK.



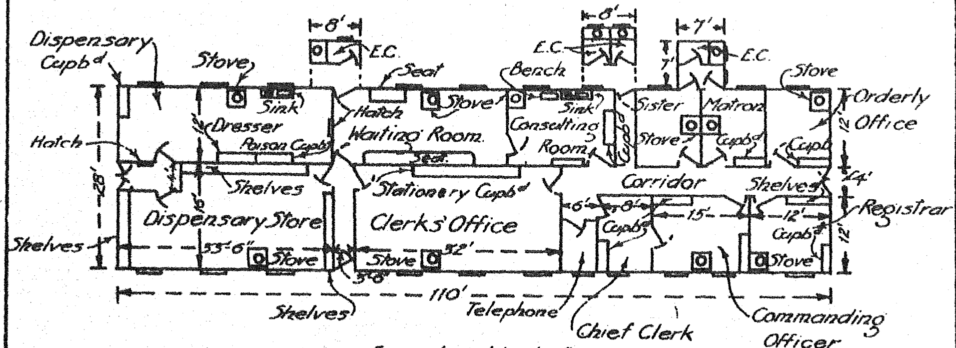
HOSPITAL BUILDINGS (1000 BEDS)



Eaves height 8'-6"

– Laboratory & General Surgical Dressing Hut –

— Fig. 1. —



Eaves height 9'-0"

– Administration Block –

— Fig. 2. —

HOSPITAL BUILDINGS.

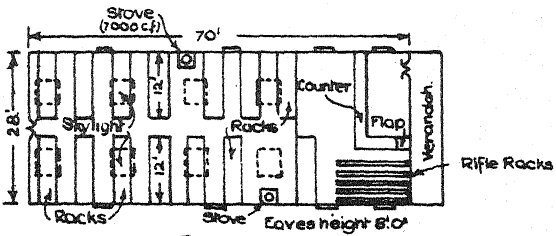


Fig. 1. Pack Store.

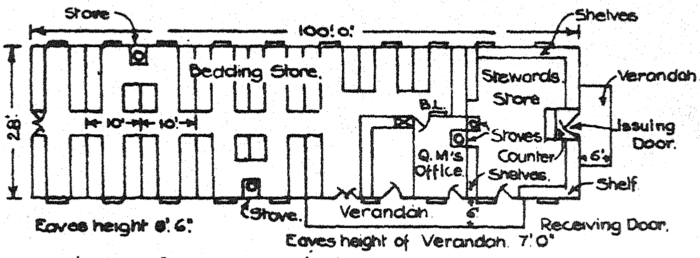


Fig. 2. Quartermaster's Stores.

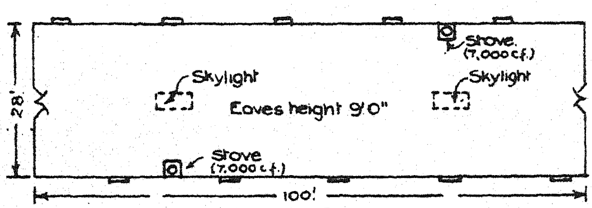


Fig. 3. Reception Room.

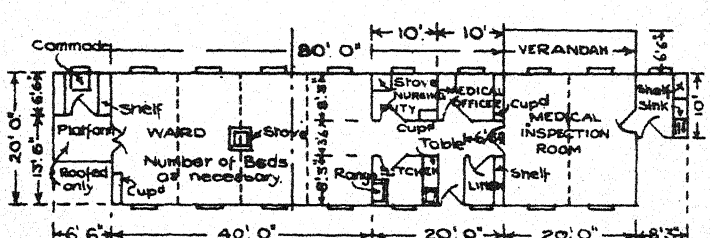


Fig. 4. Detention Ward Block

HOSPITAL BUILDINGS.

COOKING SHELTER, BATHS, & INCINERATOR & BED-PAN CLEANING SHED.

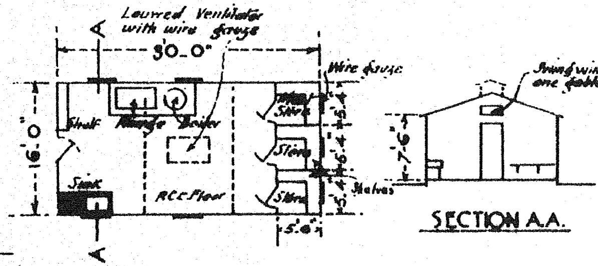


Fig. 1

ENCLOSED COOKING SHELTER.

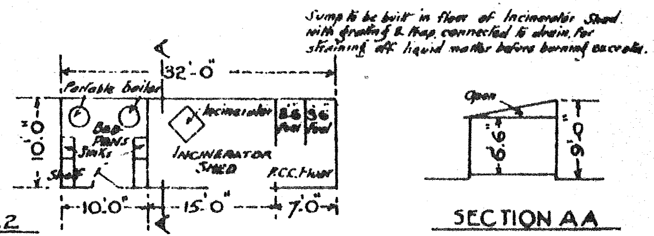


Fig. 2

INCINERATOR & BED-PAN CLEANING SHED.

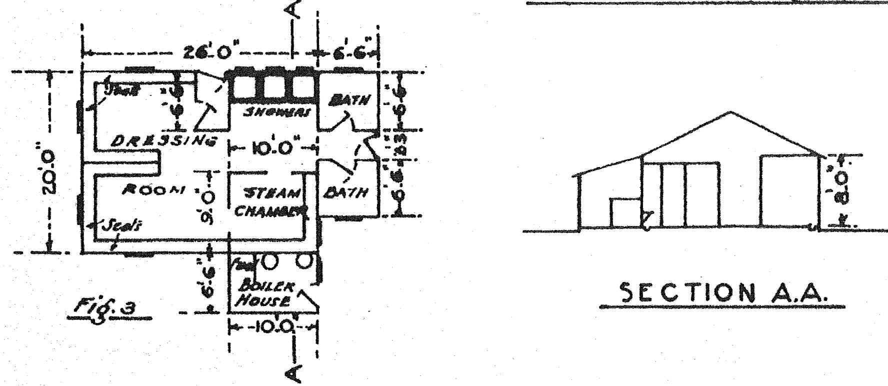
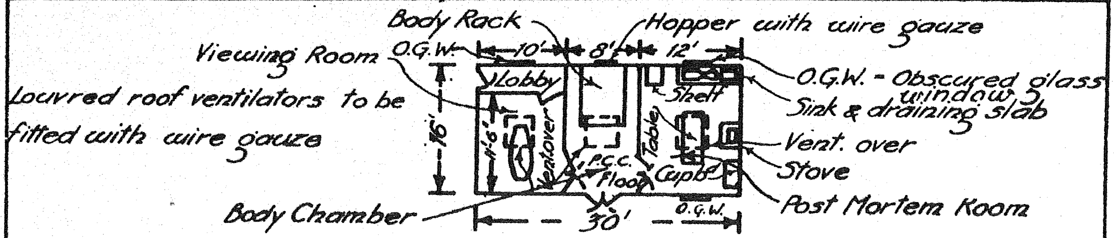


Fig. 3

BATHS (PATIENTS).

MORTUARIES.



— Fig. 1. —

Note. For 2000 bedded Hospitals,

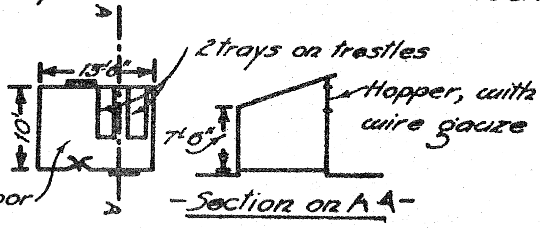
Length of Body Chamber for 12 bodies in 2 racks = 18'.

For 3000 bedded Hospitals,

Length of Body Chamber for 18 bodies in 3 racks = 28'.

For 4000 bedded Hospitals,

Length of Body Chamber for 24 bodies in 4 racks = 38'.

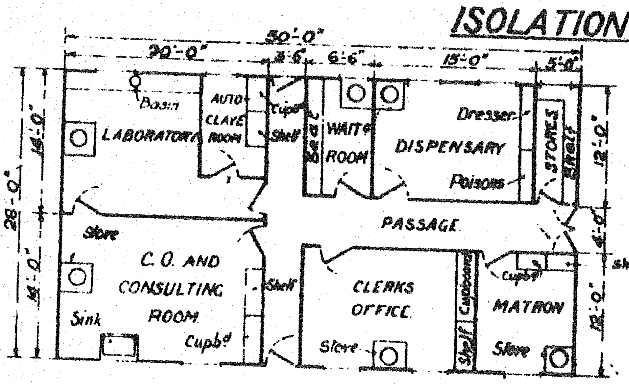


— Section on A A —

— for Isolation Hospitals —

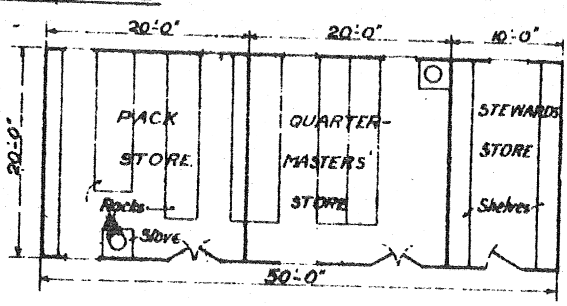
— Fig. 2. —

ISOLATION HOSPITAL.



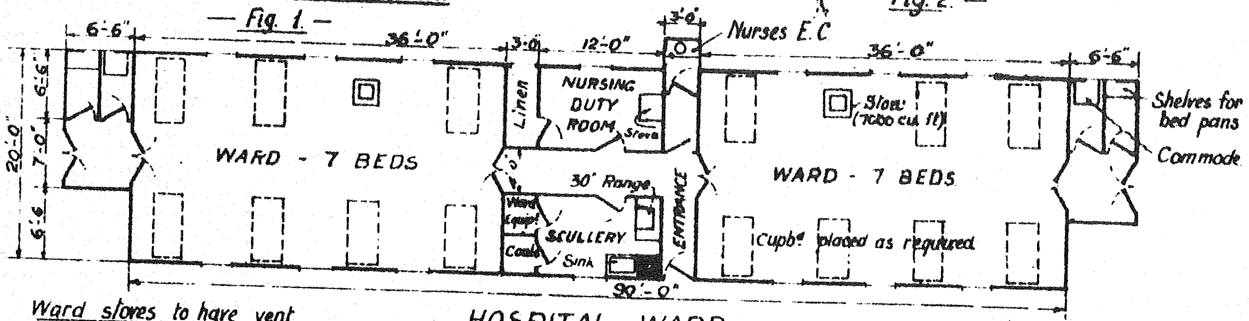
ADMINISTRATION BLOCK.

— Fig. 1. —



STORES

— Fig. 2. —



Ward stores to have vent flue-pipes with cowls.

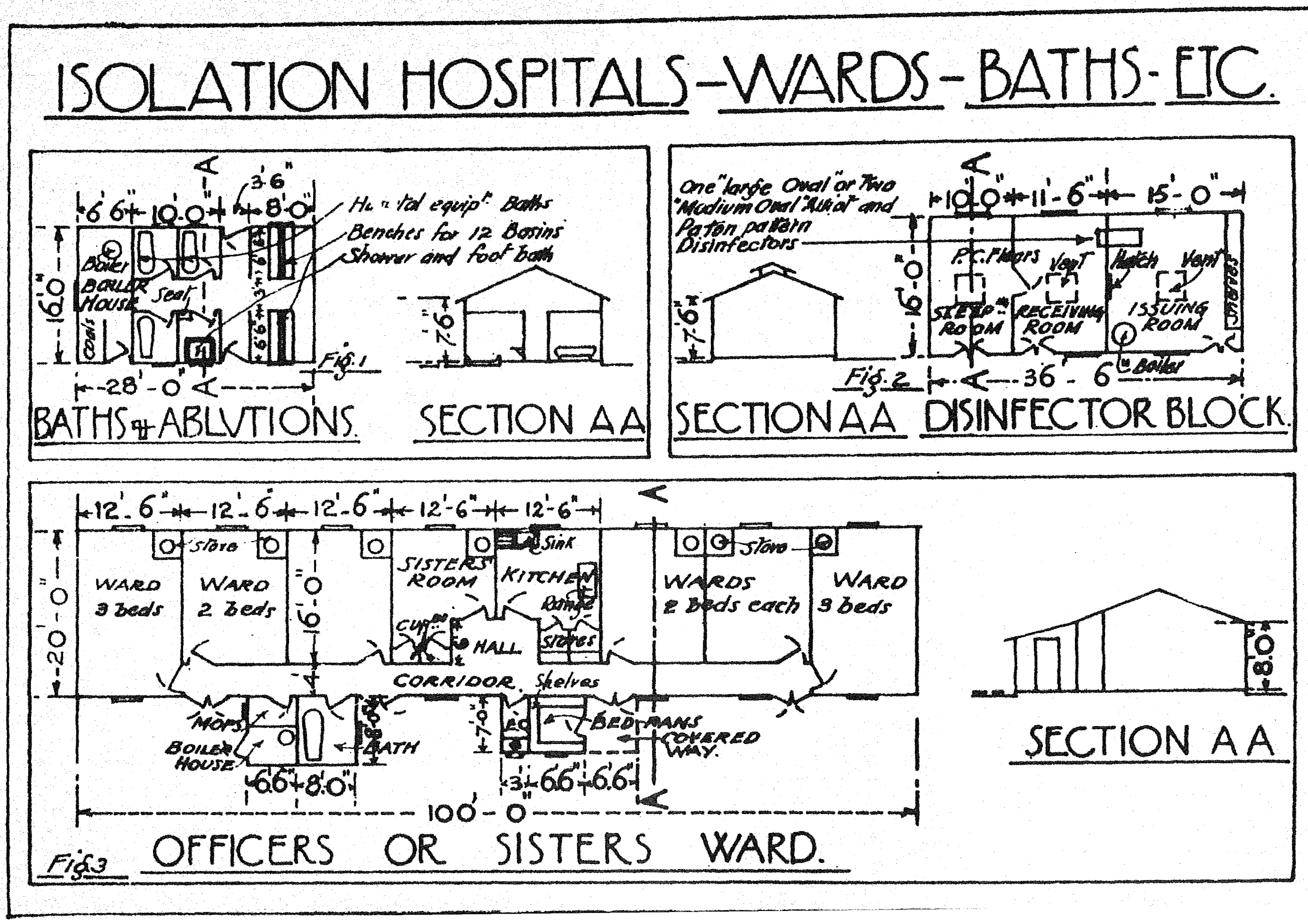
HOSPITAL WARD

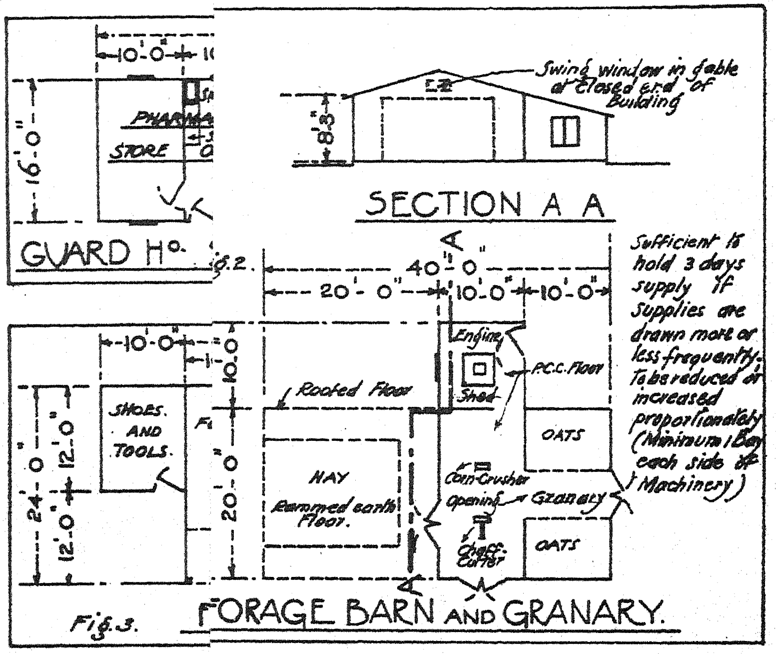
— Fig. 3. —

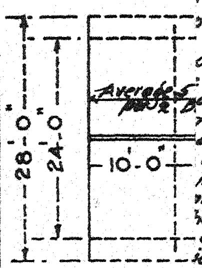
Eaves height 8'-6"

Swing windows in gable ends

SCALE 10 0 10 20 30 40

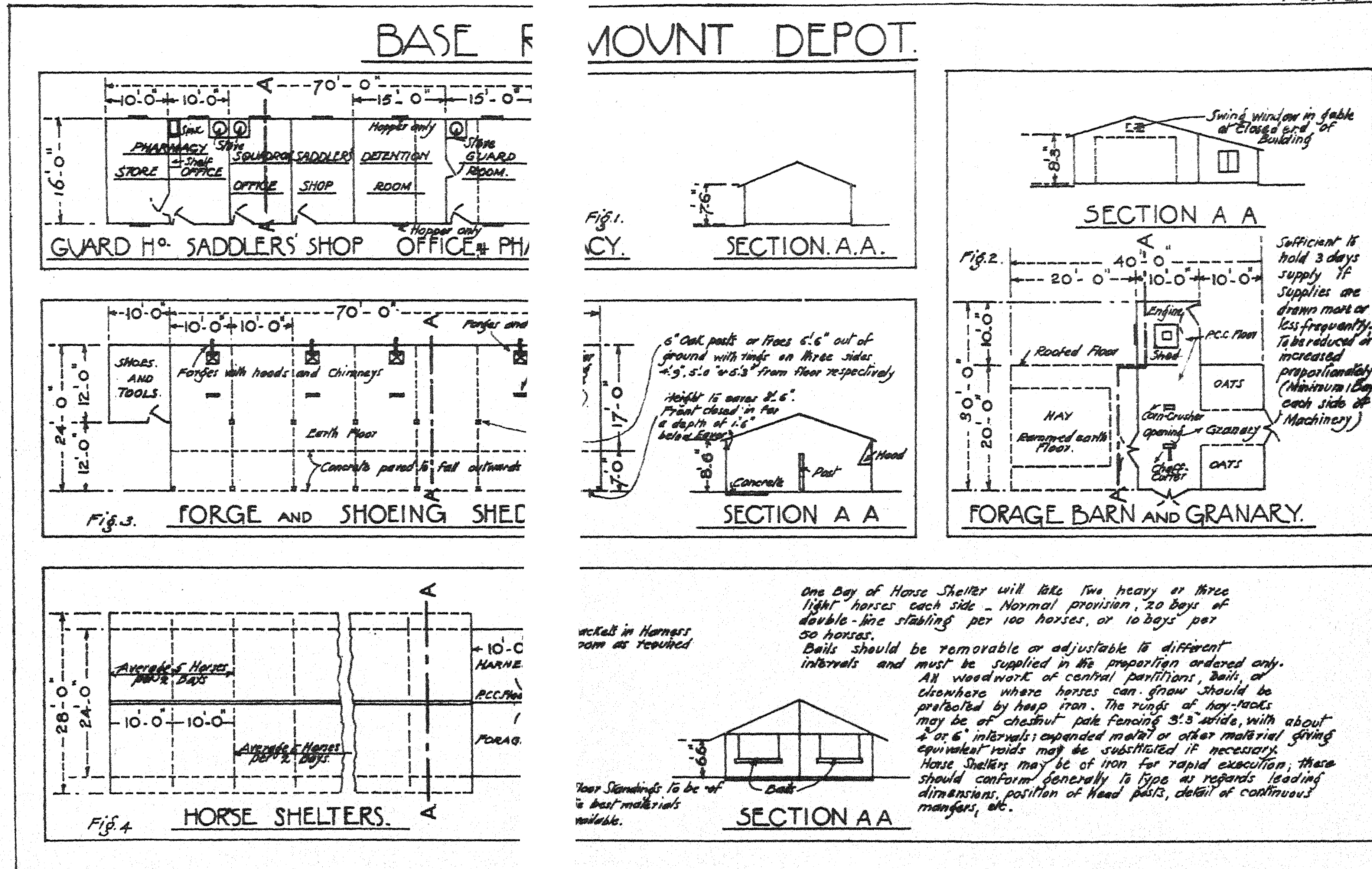

ISOLATION HOSPITALS—WARDS—BATHS—ETC.
6'6" 10'0" 3'6" 8'0"
Baths
Benches for 12 Basins
Shower and foot bath
16'0"
Boiler
BOILER HOUSE
Seat
Coals
28'0"
7'6"
Fig. 1
BATHS & ABLUTIONS.
SECTION AA
One "large Oval" or Two "Medium Oval" and Paton pattern Disinfectors
10'0" 11'6" 15'0"
16'0"
7'6"
P.C. Floors
Vent
Hatch
Vent
SLEEP. ROOM
RECEIVING ROOM
ISSUING ROOM
Boiler
Fig. 2
36'6"
SECTION AA
DISINFECTOR BLOCK.
12'6" 12'6" 12'6" 12'6" 12'6"
Store
Sink
Store
WARD 3 beds
WARD 2 beds
16'0"
SISTERS' ROOM
KITCHEN
Range
WARDS 2 beds each
WARD 3 beds
20'0"
CUP'D
HALL
Stores
CORRIDOR
Shelves
MOPS
BOILER HOUSE
BATH
7'0"
BED PANS
COVERED WAY.
6'6" 8'0"
3' 6'6" 6'6"
100'0"
8'0"
SECTION AA
Fig. 3
OFFICERS OR SISTERS WARD.

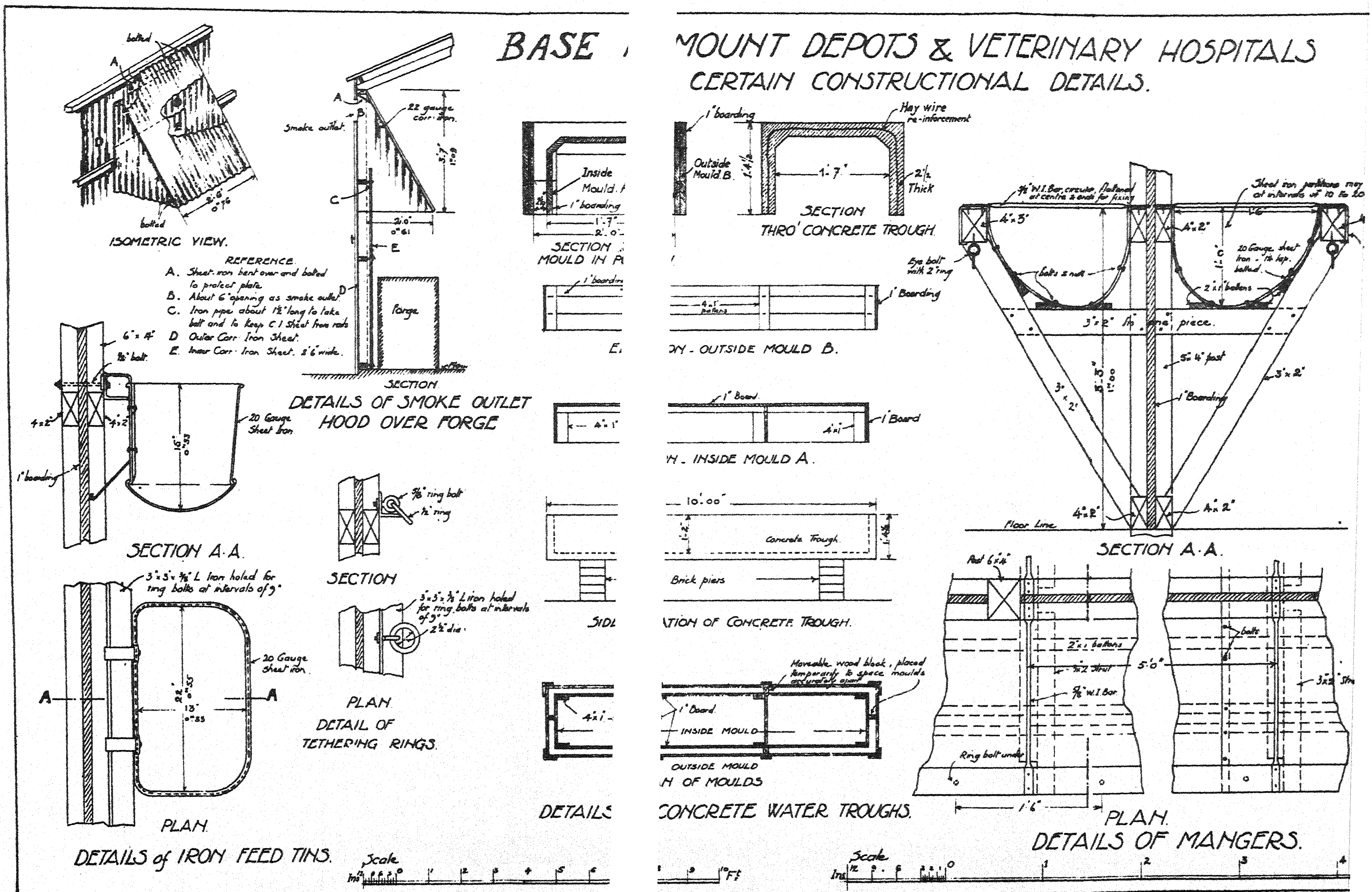




...er will take two heavy or three ... – Normal provision, 20 bays of ... per 100 horses, or 10 bays per

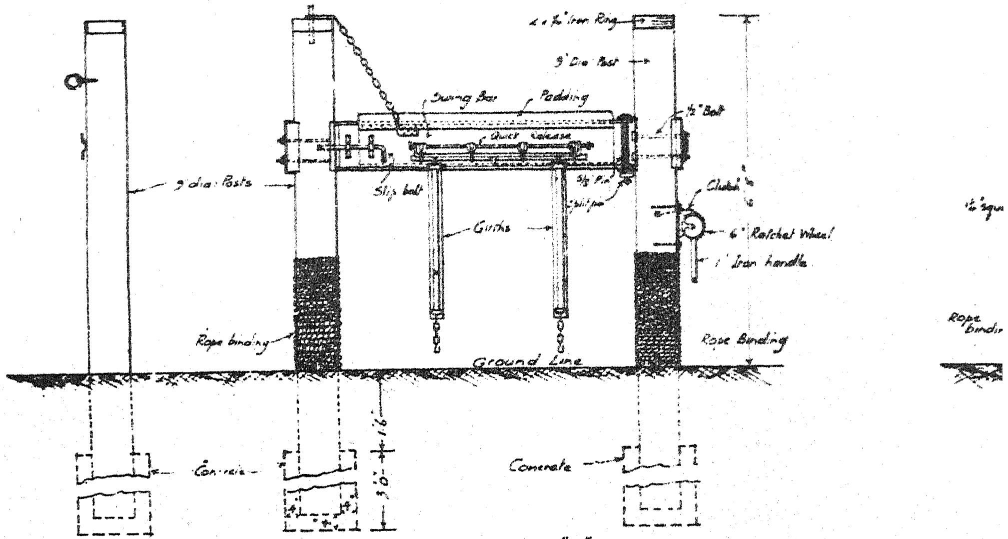
...ovable or adjustable to different ... supplied in the proportion ordered only. ...edwork of central partitions, bails, or ...re where horses can gnaw should be ...d by hoop iron. The rungs of hay-racks ... of chestnut pale fencing 3'.3" wide, with about ... intervals; expanded metal or other material giving ...t voids may be substituted if necessary. ...helters may be of iron for rapid execution; these ... conform generally to type as regards leading ...ions, position of head posts, detail of continuous ... etc.


BASE R MOUNT DEPOT.
GUARD Hᵒ. SADDLERS' SHOP OFFICE & PH/ ACY.
PHARMACY STORE
Shelf OFFICE
SQUADRON OFFICE
SADDLERS' SHOP
DETENTION ROOM
GUARD ROOM.
Hopper only
Store
Sink
Fig.1.
SECTION. A.A.
Fig.3. FORGE AND SHOEING SHED
SHOES AND TOOLS.
Forges with hoods and Chimneys
Earth Floor
Concrete paved to fall outwards
6" Oak posts or trees 6'.6" out of ground with rings on three sides 4'.9", 5'.0" & 5'.3" from floor respectively
Height to eaves 8'.6". Front closed in for a depth of 1'.6" below Eaves
Concrete
Post
Hood
SECTION A A
SECTION A A
Swing window in gable at Closed end of Building
Fig.2.
Rooted Floor
Engine Shed
P.C.C. Floor
OATS
HAY
Rammed earth Floor.
Corn Crusher
Opening
Granary
Chaff Cutter
OATS
FORAGE BARN AND GRANARY.
Sufficient to hold 3 days supply. If supplies are drawn more or less frequently, to be reduced or increased proportionately. (Minimum 1 Bay each side of Machinery)
Fig.4 HORSE SHELTERS.
Average 5 Horses per 2 Bays
Average 5 Horses per 2 Bays
HARNE
P.C.C. Floo
FORAG
ackets in Harness oom as required
loor Standings to be of e best materials vailable.
Bails
SECTION AA
One Bay of Horse Shelter will take two heavy or three light horses each side. Normal provision, 20 bays of double-line stabling per 100 horses, or 10 bays per 50 horses.
Bails should be removable or adjustable to different intervals and must be supplied in the proportion ordered only.
All woodwork of central partitions, bails, or elsewhere where horses can gnaw should be protected by hoop iron. The rungs of hay-racks may be of chestnut pale fencing 3'.3" wide, with about 4" or 6" intervals; expanded metal or other material giving equivalent voids may be substituted if necessary.
Horse Shelters may be of iron for rapid execution; these should conform generally to type as regards leading dimensions, position of head posts, detail of continuous mangers, etc.

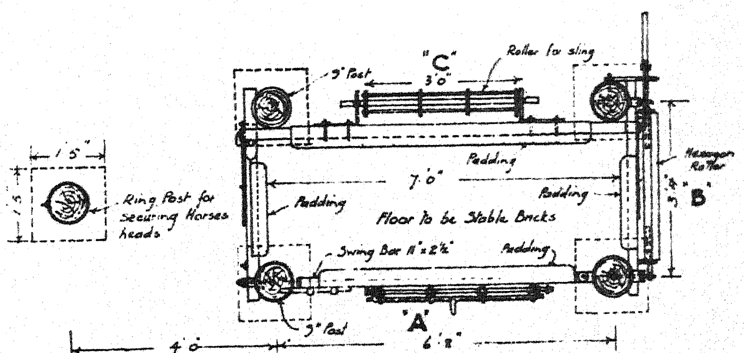


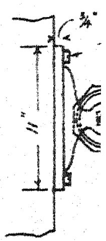
BASE MOUNT DEPOTS & VETERINARY HOSPITALS
CERTAIN CONSTRUCTIONAL DETAILS.
ISOMETRIC VIEW.
REFERENCE.
A. Sheet-iron bent over and bolted to protect plate.
B. About 6" opening as smoke outlet.
C. Iron pipe about 1½" long to take bolt and to keep C.I. Sheet from rafts
D. Outer Corr. Iron Sheet.
E. Inner Corr. Iron Sheet. 2'6" wide.
22 gauge corr. iron.
Smoke outlet.
Forge
Floor
SECTION
DETAILS OF SMOKE OUTLET HOOD OVER FORGE
SECTION A.A.
20 Gauge Sheet Iron
1" boarding
3"×3"×⅜" L Iron holed for ring bolts at intervals of 9"
20 Gauge sheet iron
PLAN.
DETAILS of IRON FEED TINS.
⅝" ring bolt
1½" ring
SECTION
PLAN.
DETAIL OF TETHERING RINGS.
Inside Mould
1" boarding
Outside Mould B.
Hay wire re-inforcement
2½ Thick
SECTION THRO' CONCRETE TROUGH.
OUTSIDE MOULD B.
INSIDE MOULD A.
10'.00"
Concrete Trough
Brick piers
ATION OF CONCRETE TROUGH.
Moveable wood block, placed temporarily to space moulds accurately apart
INSIDE MOULD
OUTSIDE MOULD
OF MOULDS
DETAILS CONCRETE WATER TROUGHS.
⅝" W.I. Bar, circular, flattened at centre & ends for fixing
Sheet iron partitions may at intervals of 10 to 20
20 Gauge sheet iron - 1½ lap. bolted.
Eye bolt with 2" ring
Bolts & nuts
2"×1" battens
3"×2" in one piece.
5"×4" post
1" Boarding
Floor Line
SECTION A·A.
Post 6"×4"
2"×1 battens
⅝" W.I. Bar
Ring bolt under
5'.0"
1'.6"
PLAN.
DETAILS OF MANGERS.
Scale

DETAILS OF STOCKS
FOR SHOEING RESTIVE HORSES

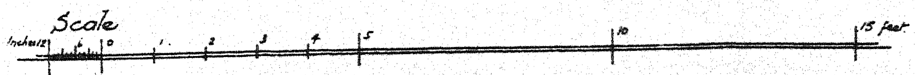


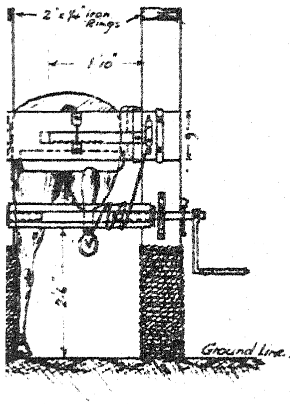
ELEVATION AT "A".



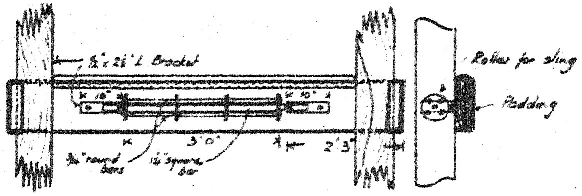


SIDE VIEW O
AT BACK OF
Scale

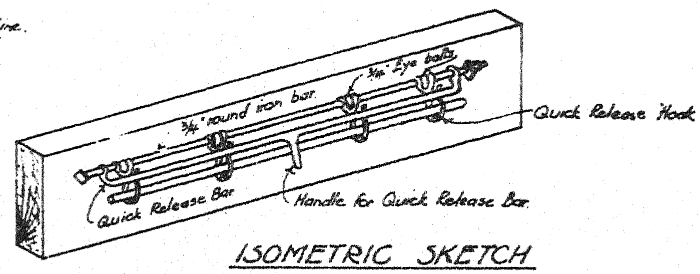




EVATION AT "B"

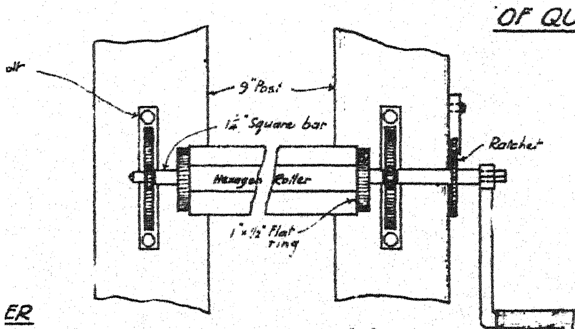


ELEVATION AT "C".

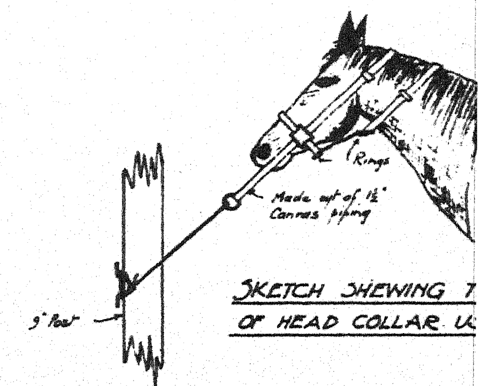


ISOMETRIC SKETCH
OF QUICK RELEASE.

ER



DETAIL AT "B"
Scale



SKETCH SHEWING T
OF HEAD COLLAR U

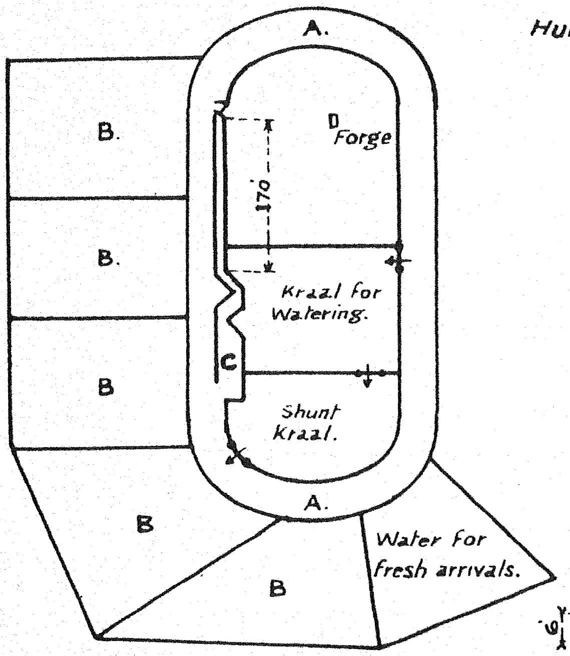
Plate 68.

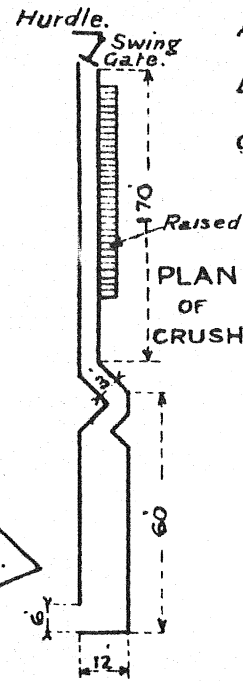
THE KRAAL SYSTEM.

A. Railed exercising track 30 ft. wide 400 to 600 yards long.

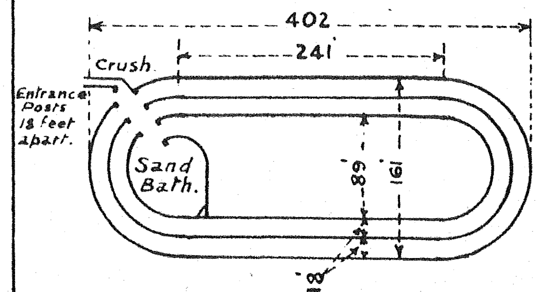
B. Paddocks each opening onto the track.

C. Crush for passing horses slowly in review.

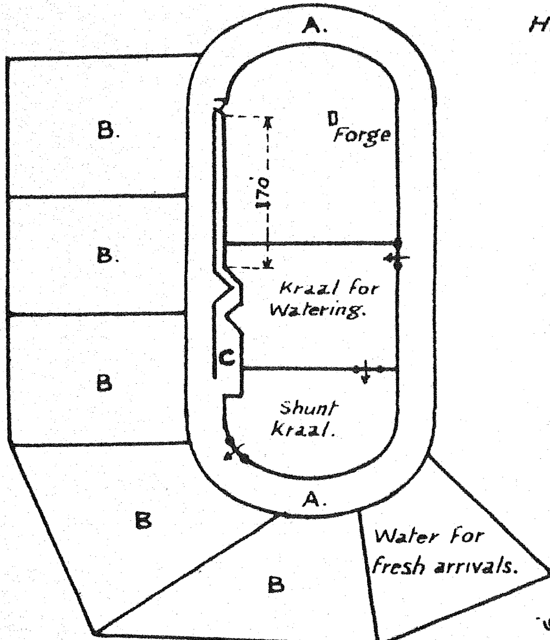


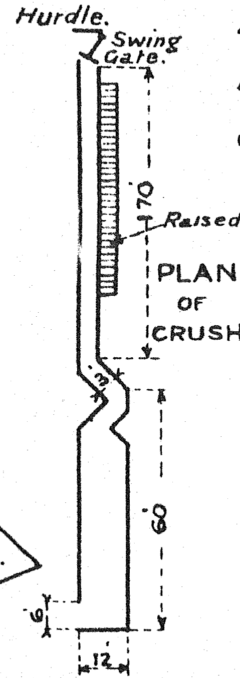


EXERCISING TRACK & CRUSH.



THE KRAAL SYSTEM.





A. Railed exercising track 30 ft. wide 400 to 600 yards long.

B. Paddocks each opening onto the track.

C. Crush for passing horses slowly in review.

EXERCISING TRACK & CRUSH.

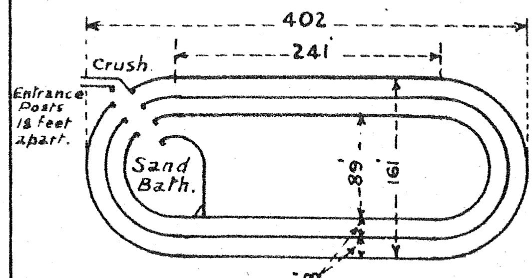
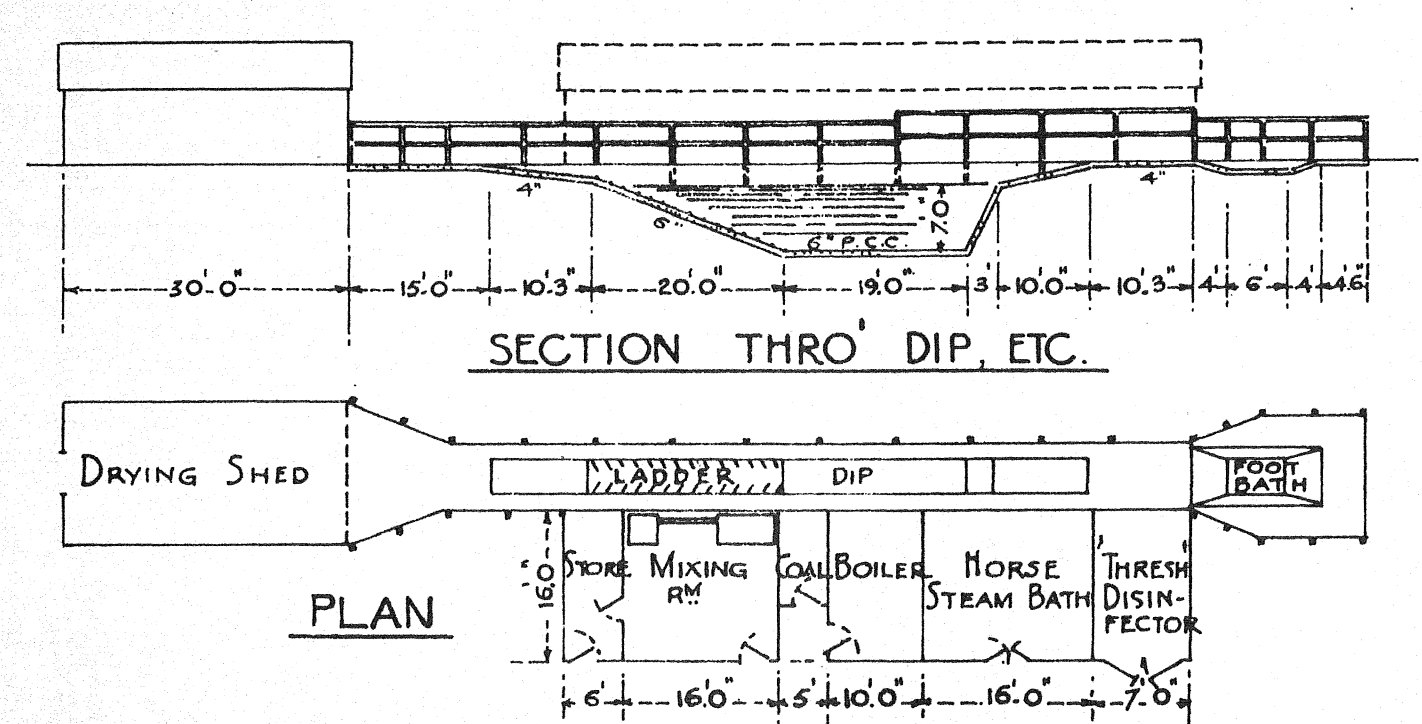


Plate 68.

VETERINARY HOSPITAL–HORSE DIP & ACCESSORY BUILDINGS.



_R.

ACCESS(. (30 HORSES.)

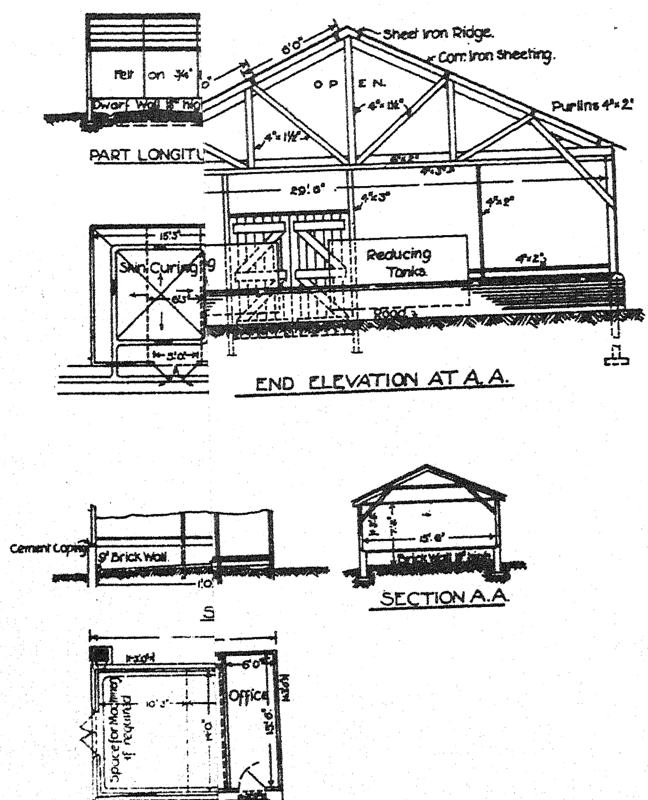
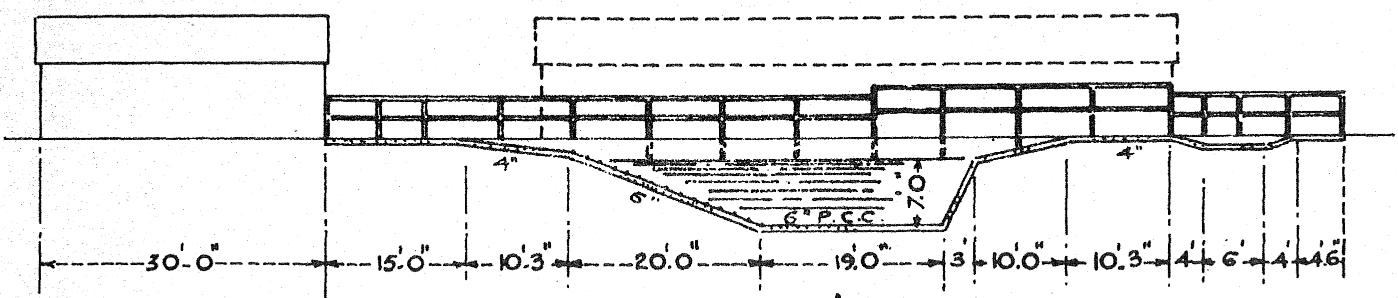
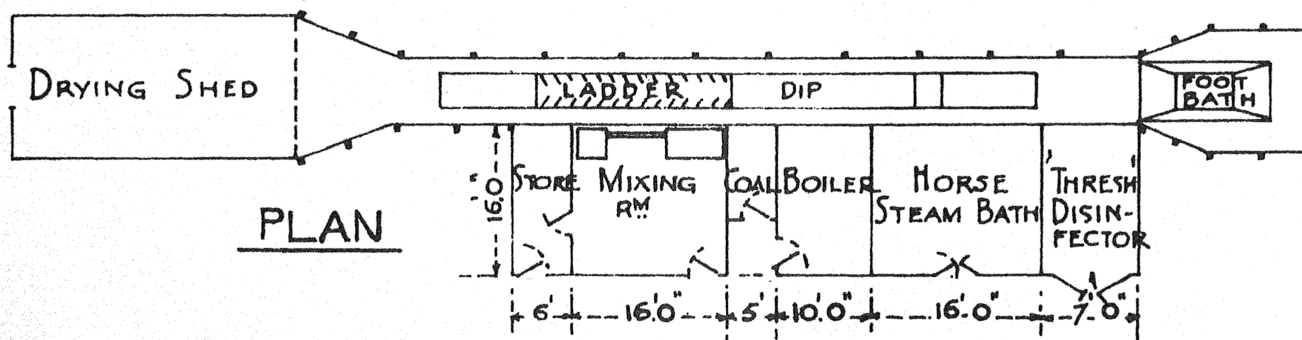


PLATE 69.

VETERINARY HOSPITAL—HORSE DIP & ACCESSORY BUILDINGS.



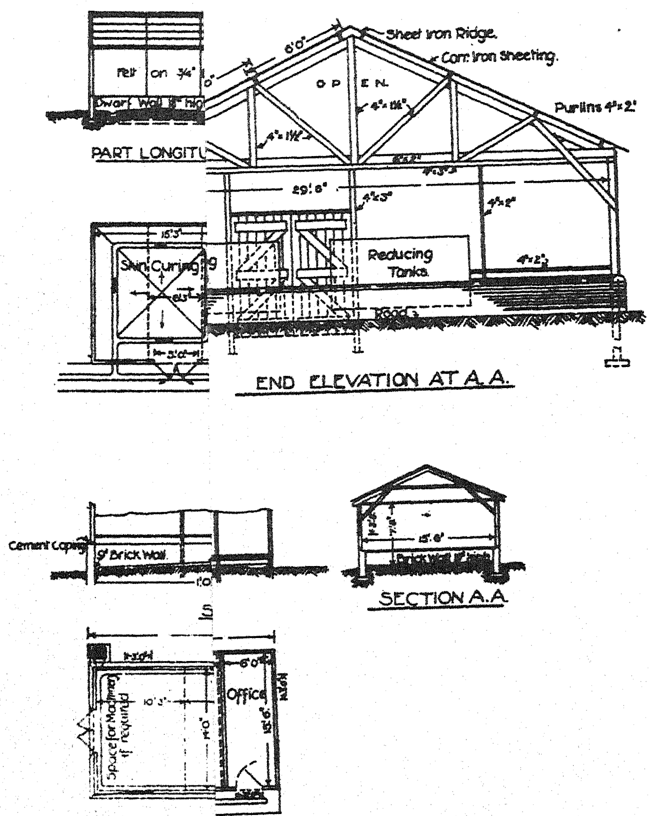
SECTION THRO' DIP, ETC.



PLAN

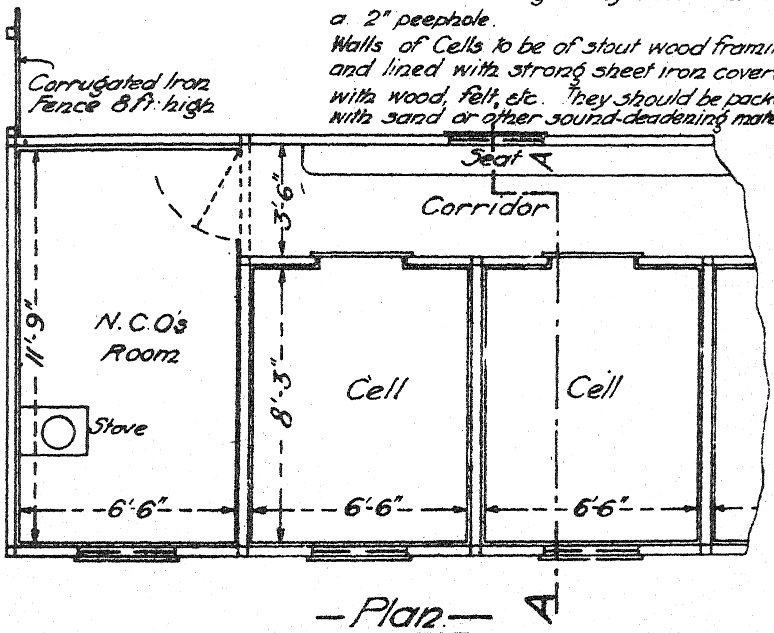
_R.

ACCESS(. (30 HORSES.)

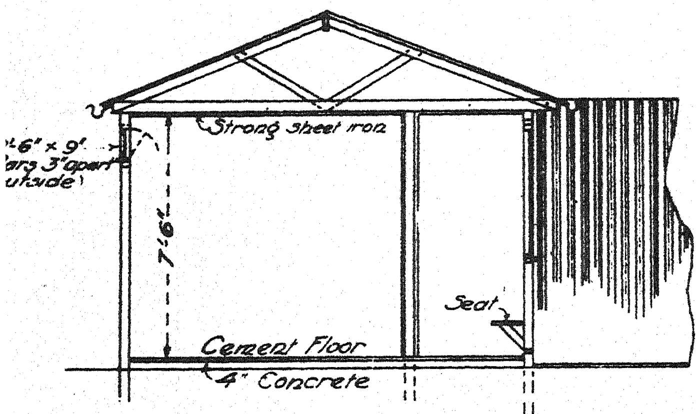


MILITARY PRISON.

Doors of Cells to slide and have strong iron bar fastenings. They should have a 2" peephole.
Walls of Cells to be of stout wood framing and lined with strong sheet iron covered with wood, felt, etc. They should be packed with sand or other sound-deadening material.

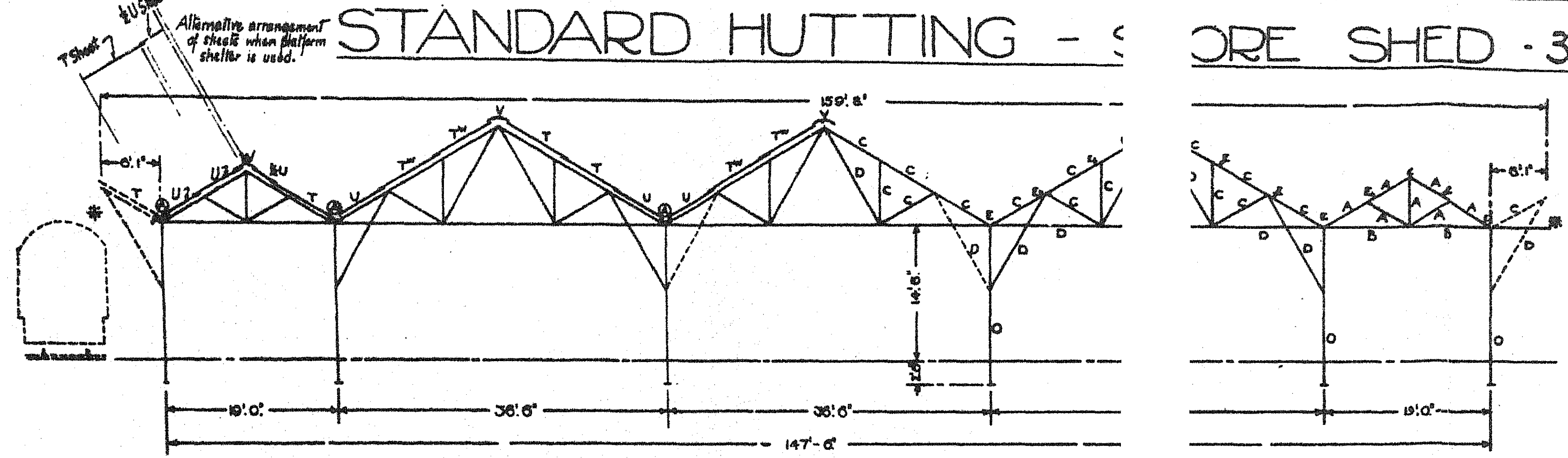


— Plan —



— Section on A A —

STANDARD HUTTING - STORE SHED - 381'.7" × 148'.1"



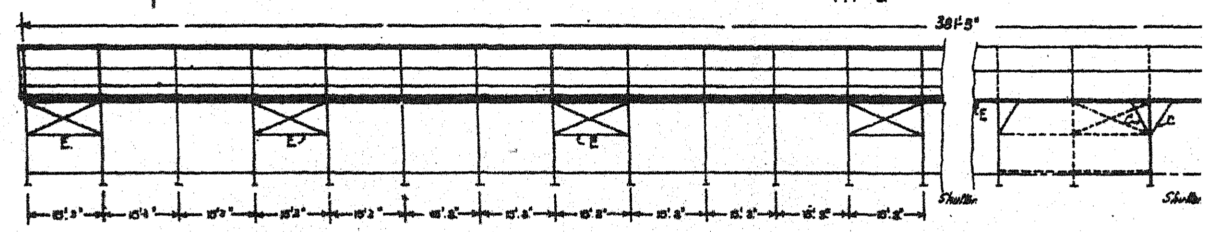
LIST OF QUANTITIES FOR SHED.					
MARK	NUMBER	DESCRIPTION	MARK	NUMBER	DESCRIPTION
A	364	Framing bars 5'.5 3/16" centres of eyes	Z	46656	Galvd. Sheeting Bolts & Washers, 5/16" × 1/2".
B	104	" " 9'.6" " " "	T	2884	" Corrugated Iron Sheets, 7'6"×8/3" 24G
C	828	" " 7'.0 3/4" " " "	T^W	1140	" " " (7'6") with windows
D	564	" " 12'.2" " " "	U	2112	" " " 6'.0"×8/3". 24G
E	1210	" " 14'.7" " " "	V	576	" " Curved " 3'-0"×8/3". 24G
G	576	Spikes for Stanchions 4"×1/2" dia.	W	140	" Ridge Flashing 6'0"×30" Girth ×20G.
H	936	Purlin Cleats.	Y	19110	" Hook Bolts and Washers 5/16" dia.
J	156	Ventilator Brackets.	AC	264	" Valley Gutter
L	680	Bolts and Nuts. 5"×1 1/8" dia	AD	40	" " " (with Drop eyes)
M	6392	Washers 2 5/8"×1/2"	AE	300	" " " Joint covers.
N	2792	Bolts and Nuts 1 3/4"×1/2" for Purlin Cleats.	AF	8	" " " Stop Ends.
O	144	Stanchions.	AG	612	" " " Supports 2 1/2"×5/16" M.S.
P	84	Purlin Extensions	AJ	120	" R.W.P. Bracket complete with nuts & Bolts.
AH.	80.	Lengths of " Dia. R.W. Pipe.	LJ	9076.	Bolts and Nuts, 3 1/2"×1 1/8" Dia.
	24	Eaves Beams.		14.	Rolling Shutters complete with frame.
Q.	776	Framing cleats.		6.	Doors (2 leaves, each 12'×6')

For 6" concrete floor (1:2:4 Mix).
4860 cwts. of Cement.
445 yds.c. " Sand.
888 " " " Ballast.

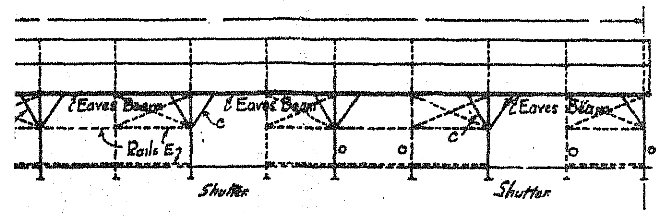
* If Platform Shelters, shewn dotted, are required, add:- 52C; 28D; 100E; 104H; 264U; 476M; 208N; 8P; 768T; 132AC; 20AD; 150AE; 4AF; 306AG; 40AH; 60AJ; 1560Y; 2300Z: And Omit 576 U.

12 0 5 10 15 20 25 30 35 40
Inches Feet
Scale for Large Section

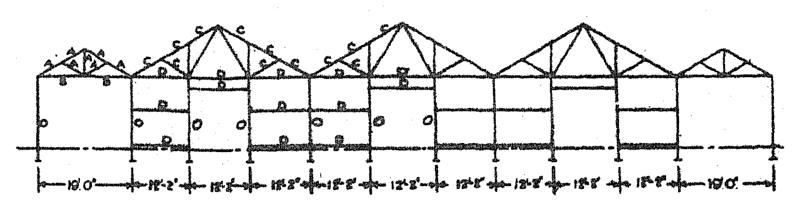
12 0 10 20 30 40 50 60 70 80
Inches Feet.
Scale for Section A.A. Side Elevn. End Framg. & Elevn.



PART SECTION A.A.

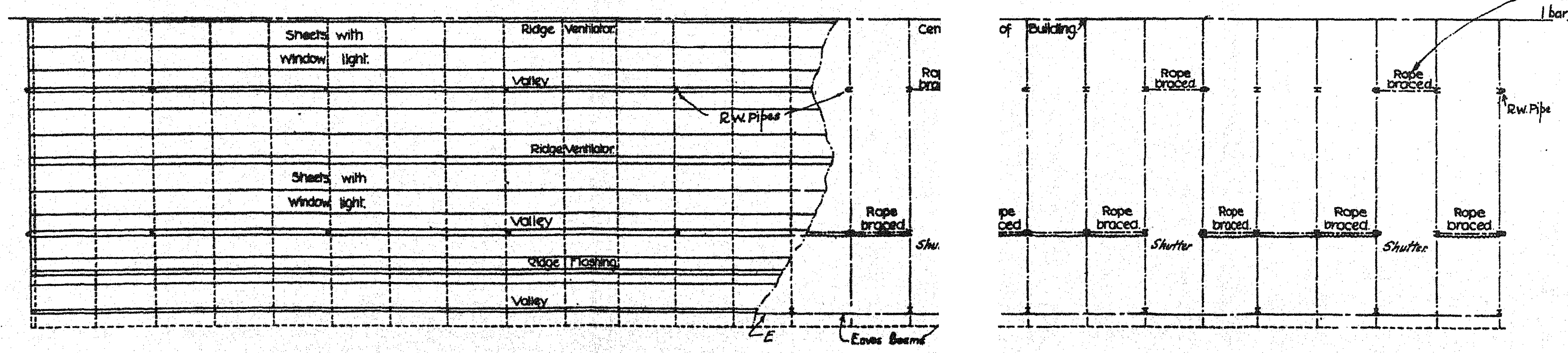


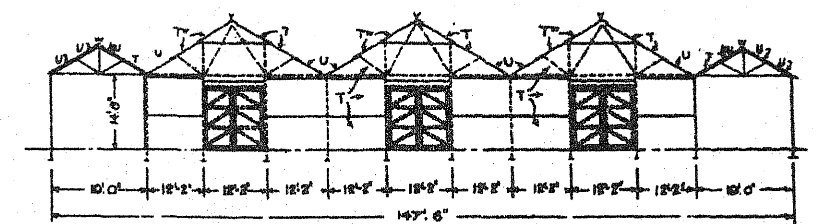
PART SIDE ELEVATION.



END FRAMING.

Note. For each bay of rope bracing add:- 1 bar E; 2 Q; 2 L; 4 N; 10 M:.

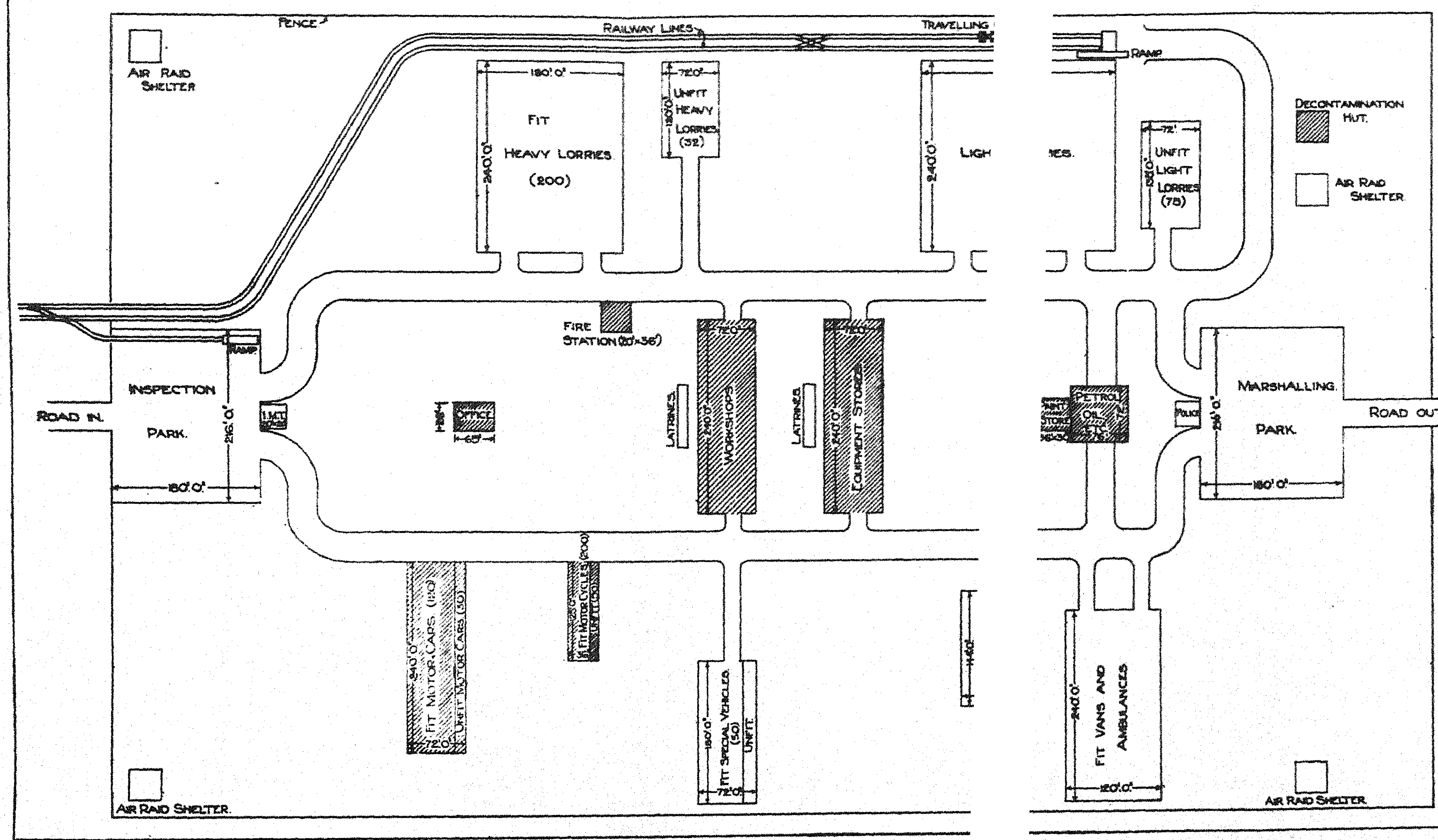




END ELEVATION.

NOTE
When lifting trusses, a scaffold pole or plank should be tied across the truss to stiffen it against buckling.

TYPICAL LAYOUT OF A M.T. VEHICLE RECEPTION DE[POT] R.A.S.C.



ALLOTMENT OF SPACE FOR APPROXIMATELY 1400 VEHICLES.

Nº OF VEHICLES	DESCRIPTION OF PARKS	AREA SQ. FT.	SIZE
FIT.			
200	HEAVY LORRIES.	43,200	240'×180'
375	LIGHT LORRIES	57,600	240'×240'
200	VANS AND AMBULANCES.	28,800	240'×120'
150	CARS (FIT AND UNFIT)	17,280	240'×72'
250	MOTOR-CYCLES & SIDECARS (FIT & UNFIT)	4,500	125'×36'
30	SPECIAL VEHICLES (FIT & UNFIT)	12,960	180'×72'
UNFIT			
32	HEAVY LORRIES.	8,640	120'×72'
75	LIGHT LORRIES.	9,720	135'×72'
60	VANS AND AMBULANCES.	10,368	144'×72'

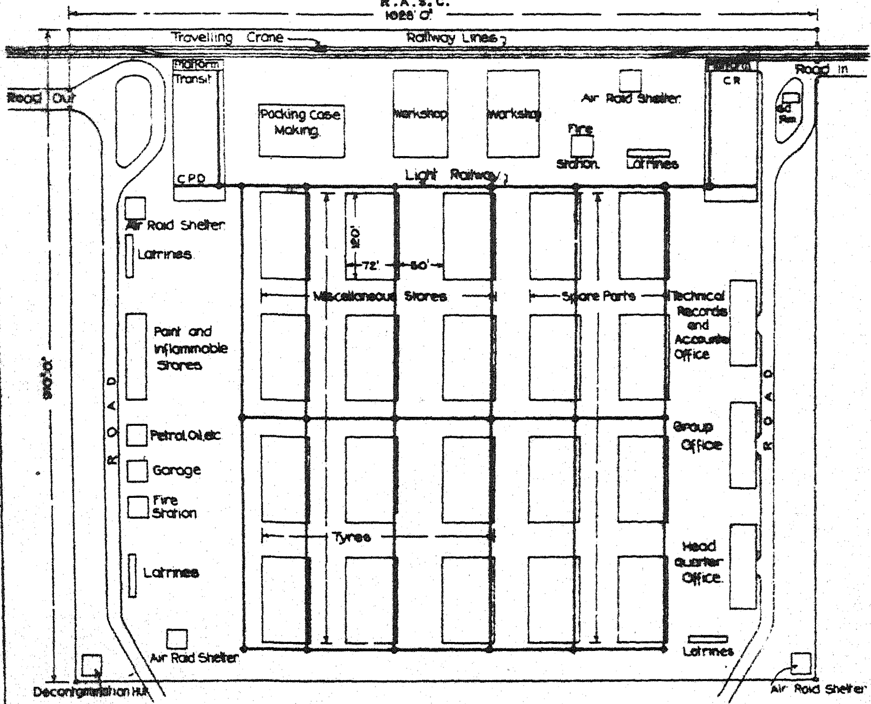
SPACE OCCUPIED - VEHICLE CAMP - 35 ACRES.
PERSONNEL CAMP - 3 "
TOTAL - 38 "

COVERED SPACE SHEWN THUS -

Plate 74.

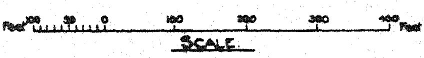
LAYOUT OF A BASE M.T. STORES DEPOT

R.A.S.C.



AREAS.

Total Area allowed - 21½ acres - 936540 sq.ft
Area enclosed by Fence - 910' × 1028 - 935480 " "
Covered Area allowed for Stores - 4 acres - 174,240 " "
Area by 20 Stores Sheds - 72 × 120 - 172800 } - 177,120 " "
" " 1 Paint Shed - 36' × 120 - 4320 }
Covered Area allowed for other buildings - 2½ acres - 108,800 " "
Area by all other buildings except Store Sheds - 73,320 " "



SCALE.

Plate 75.

BASE M.T. STORES DEPOT.

R.A.S.C.

ARRANGEMENT OF RACKS AND BINS.

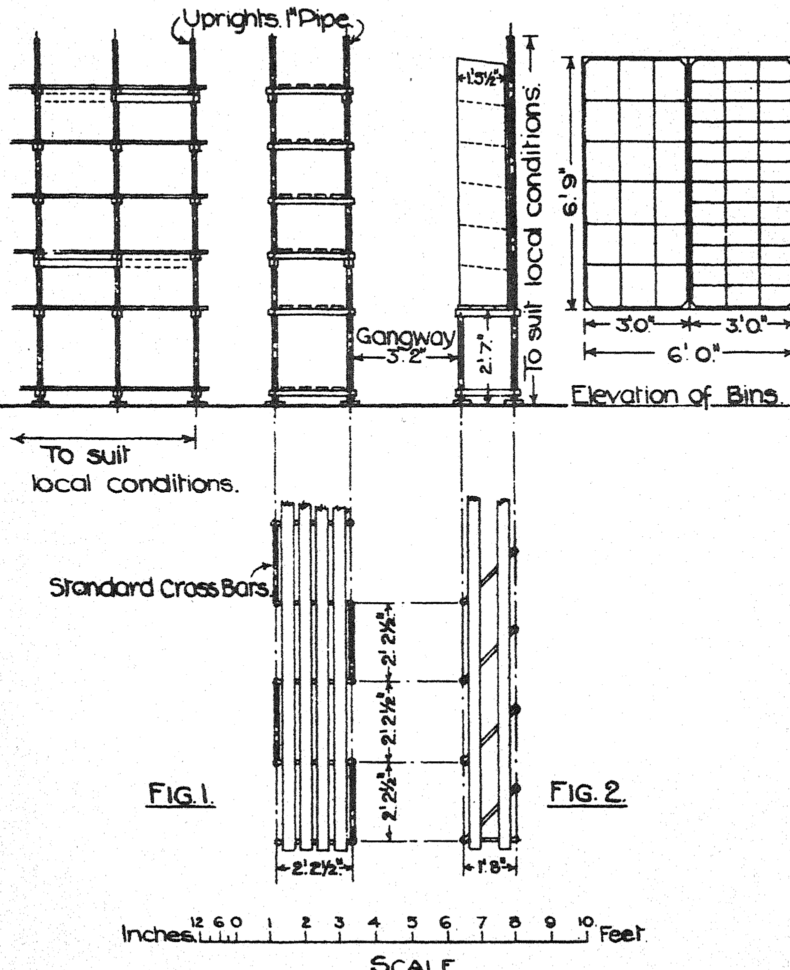


FIG. 1.

FIG. 2.

BASE M.T. STORES DEPOT. R.A.S.C.

TYRE STORES.

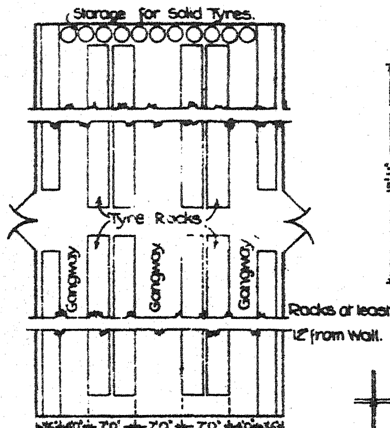


FIG. 1. SUGGESTED LAYOUT FOR A TYRE STORES.

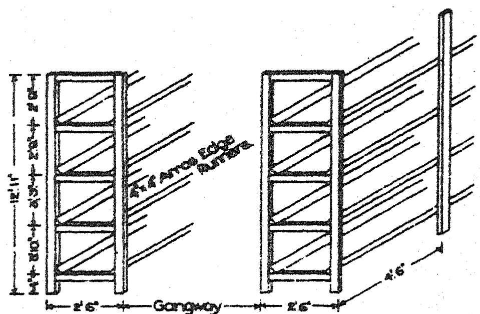


FIG. 2. WOODEN TYRE RACKS.

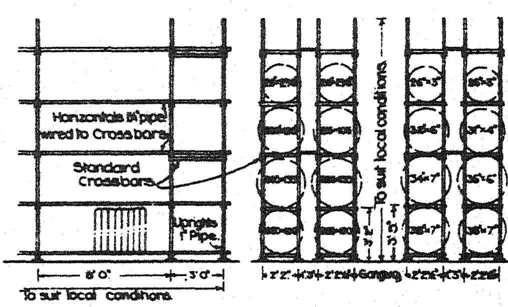


FIG. 3. METAL RACKS FOR STORING TYRES.

TYRE STORAGE.

Structure 130' long × 36' wide × 14'6" high with 4 tier racks will accomodate

Giant Tyres	1,000.
Solid Tyres	1,300.
Car Tyres	1,500.
Motor Cycle Tyres.	1680
Tubes, assorted.	12,000

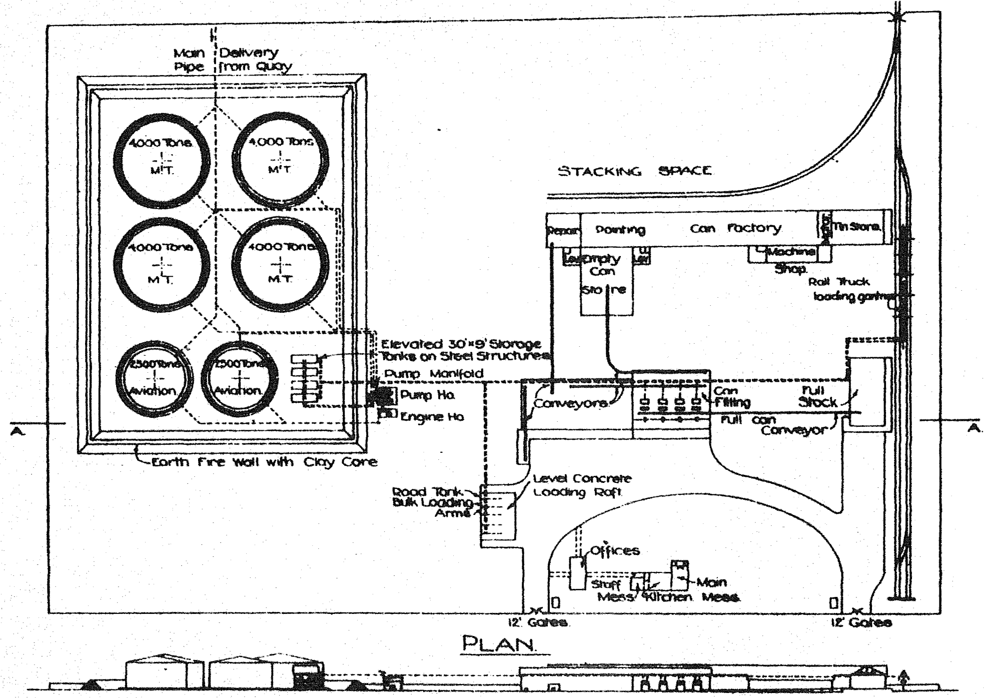
Each Rack - 60' long.

Giant Tyres.	1 shelf in each rack - 12 shelves 90 Tyres per rack - 1,080
Cars.	1 shelf in each 10 racks. 150 Tyres per rack - 1,500
Motor-Cycles	7 shelves 240 per shelf - 1680
Solid Tyres.	7 shelves 150 per shelf - 1,050 } Stored on floor } say 1,300 8 lots of 32 - 256 }
Tubes.	10 shelves approx 100' long × 4' deep × 3' high - 12,000

Plate 77.

BASE BULK PETROL DEPOT.

DIAGRAMMATIC LAYOUT.

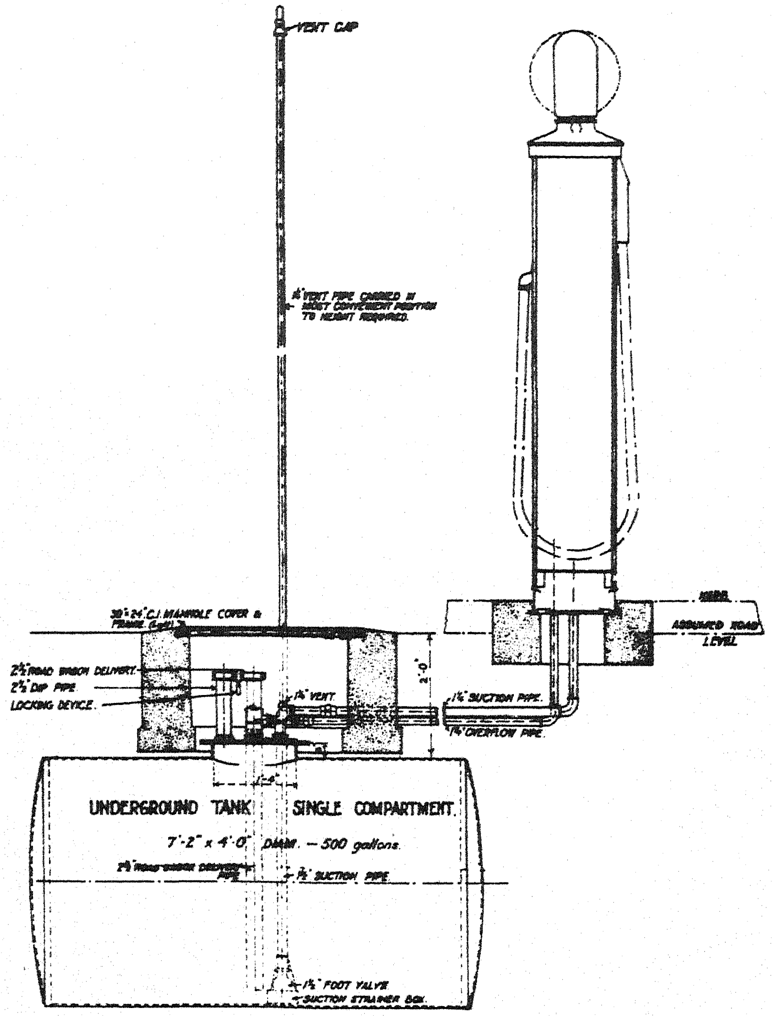


PLAN.

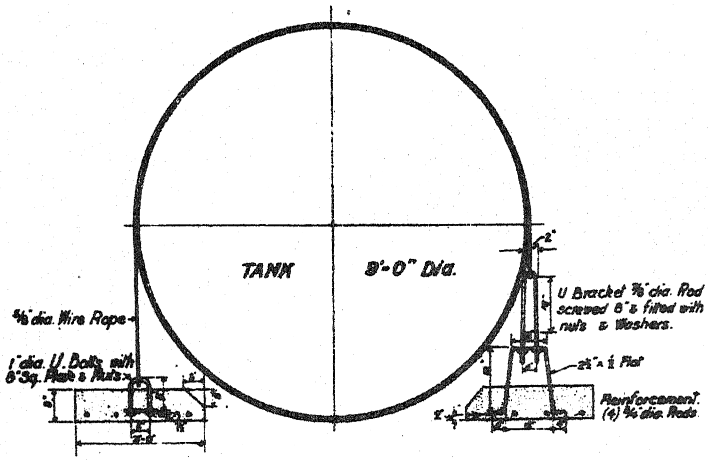
SECTION A.A.

Plate 78.

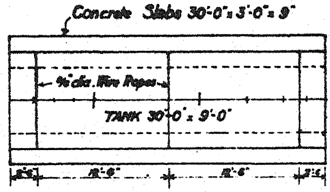
FIXED PETROL STATION

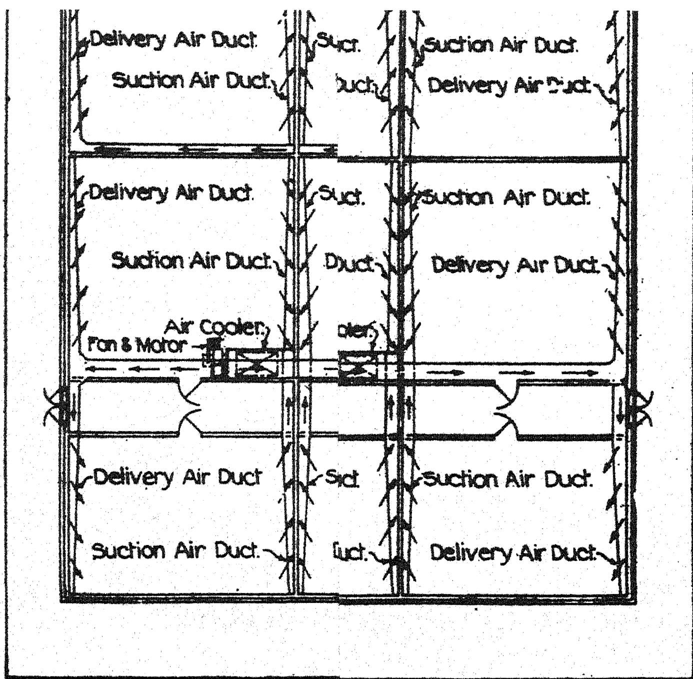


• TANK ANCHORAGE •



Concrete Slabs 30'-0" Long for 30'-0" x 9'-0" Tanks.





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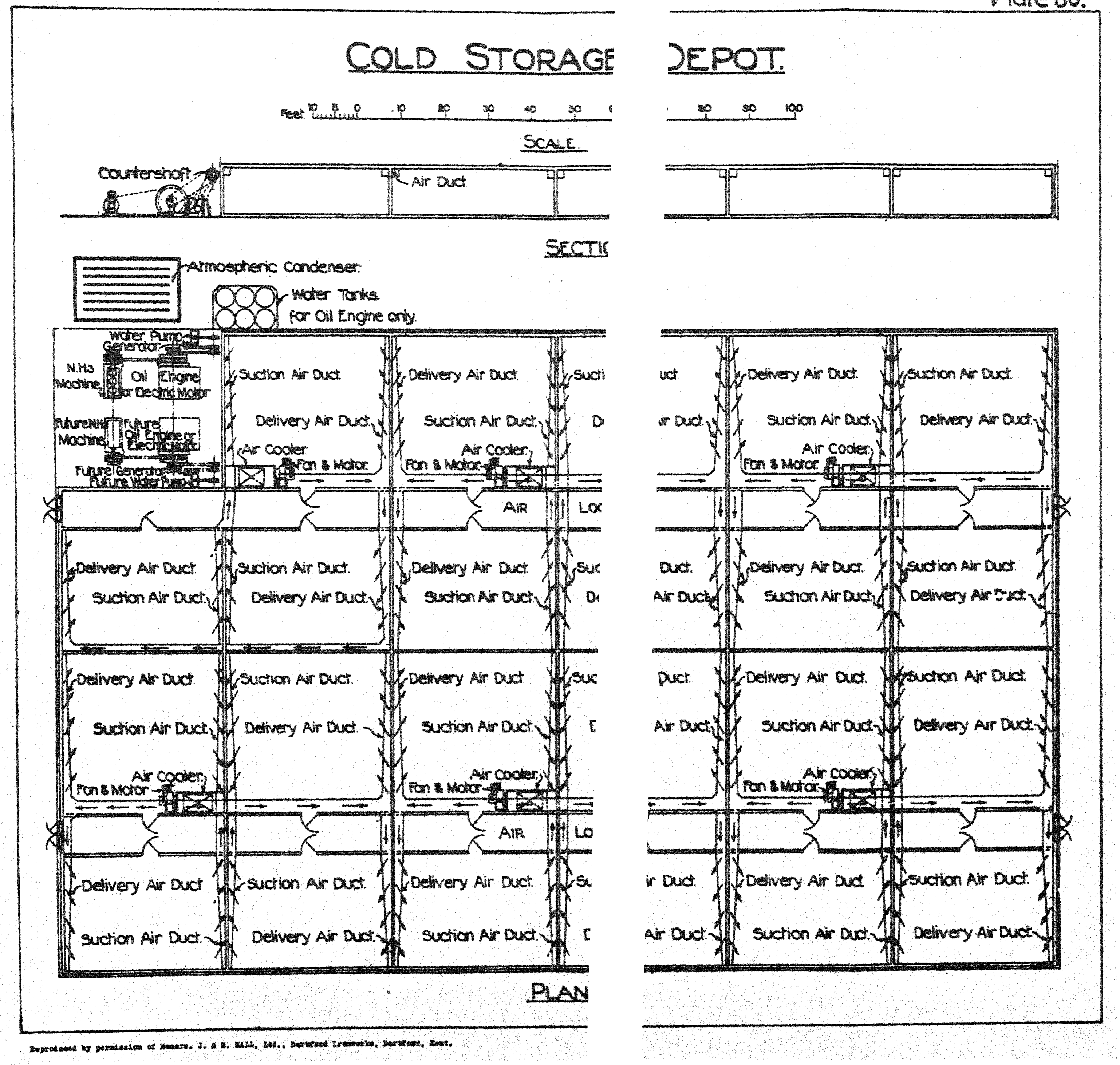

COLD STORAGE DEPOT.
Feet
SCALE.
Countershaft
Air Duct
SECTION
Atmospheric Condenser
Water Tanks for Oil Engine only.
Water Pump
Generator
N.H3 Machine
Oil Engine or Electric Motor
Future N.H3 Machine
Future Oil Engine or Electric Motor
Future Generator
Future Water Pump
Suction Air Duct
Delivery Air Duct
Air Cooler
Fan & Motor
AIR LOCK
PLAN

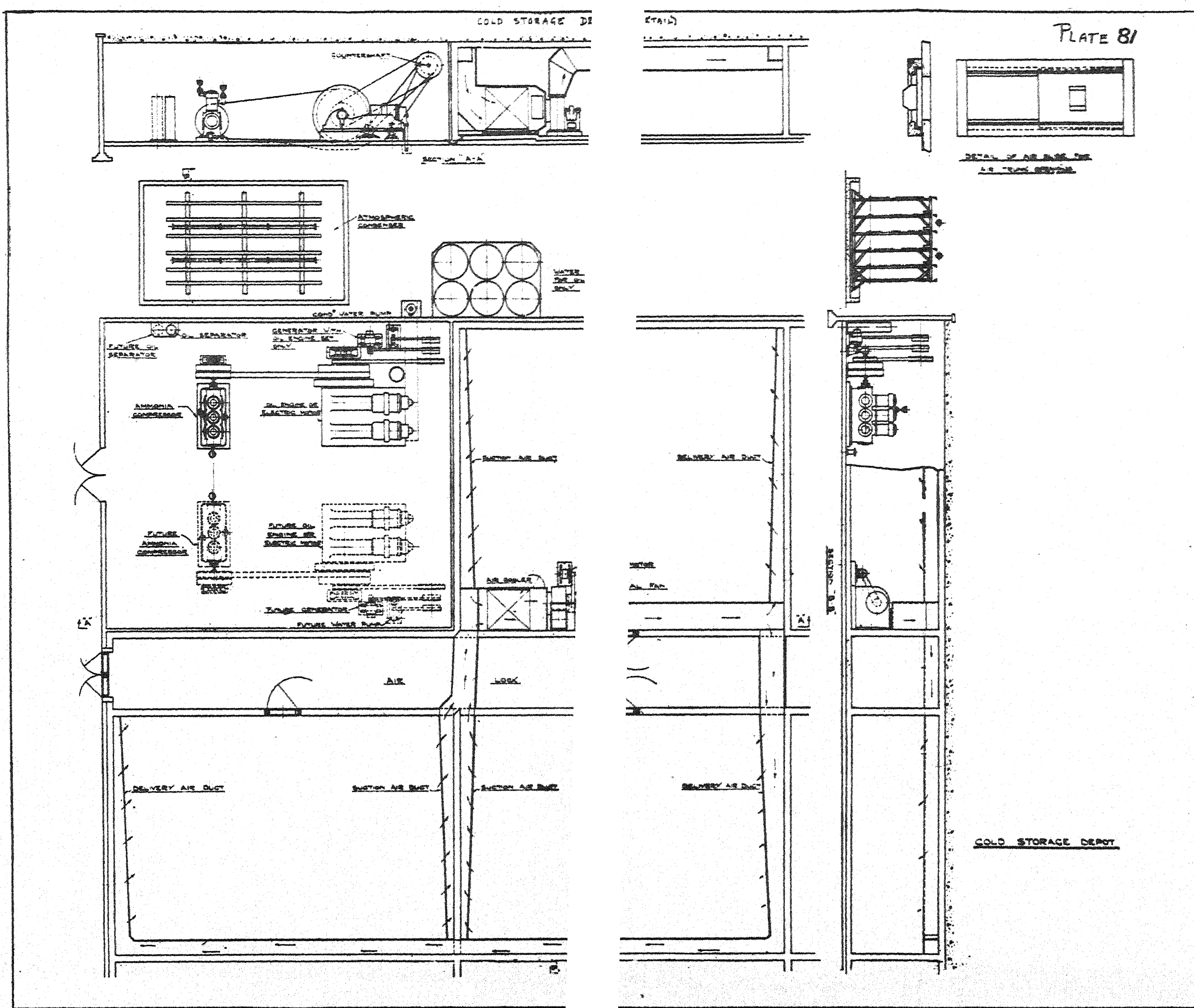
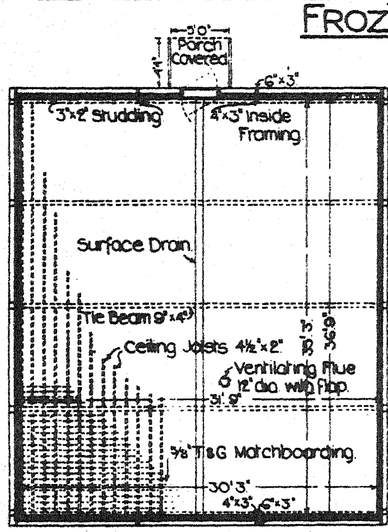


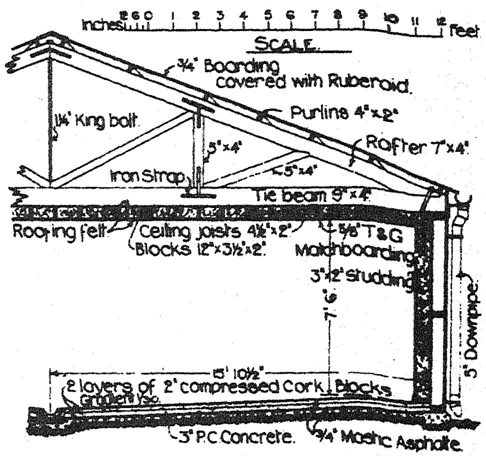
PLATE 81
COLD STORAGE DE
ETAIL
COUNTERSHAFT
SECTION "A-A"
DETAIL OF AIR SLIDE FOR AIR TRUNK OPENING
ATMOSPHERIC CONDENSER
COND WATER PUMP
OIL SEPARATOR
FUTURE OIL SEPARATOR
AMMONIA COMPRESSOR
FUTURE AMMONIA COMPRESSOR
FUTURE GENERATOR
FUTURE WATER PUMP
AIR COOLER
SUCTION AIR DUCT
DELIVERY AIR DUCT
AIR LOCK
COLD STORAGE DEPOT

Plate 82.

FROZEN MEAT STORE (TEMPORARY TYPE.)

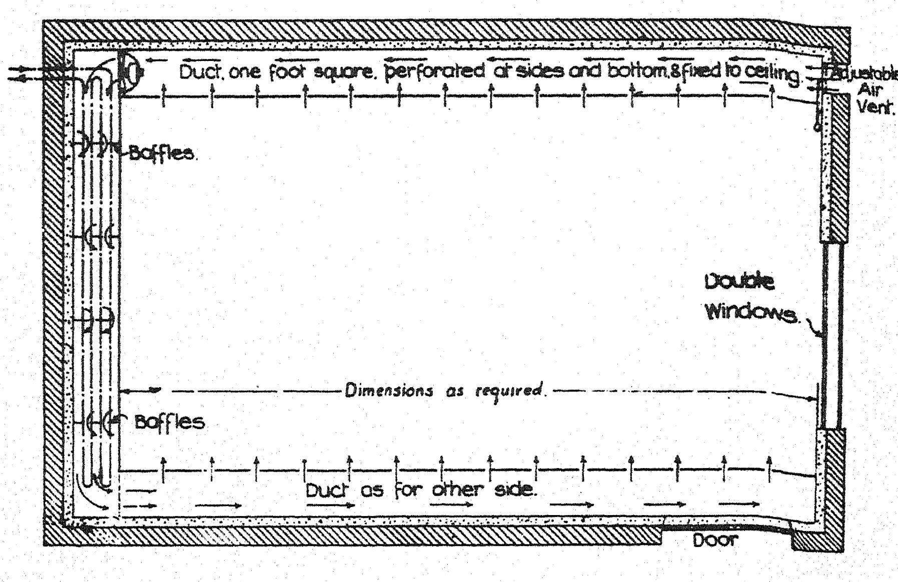


PLAN.



SECTION.

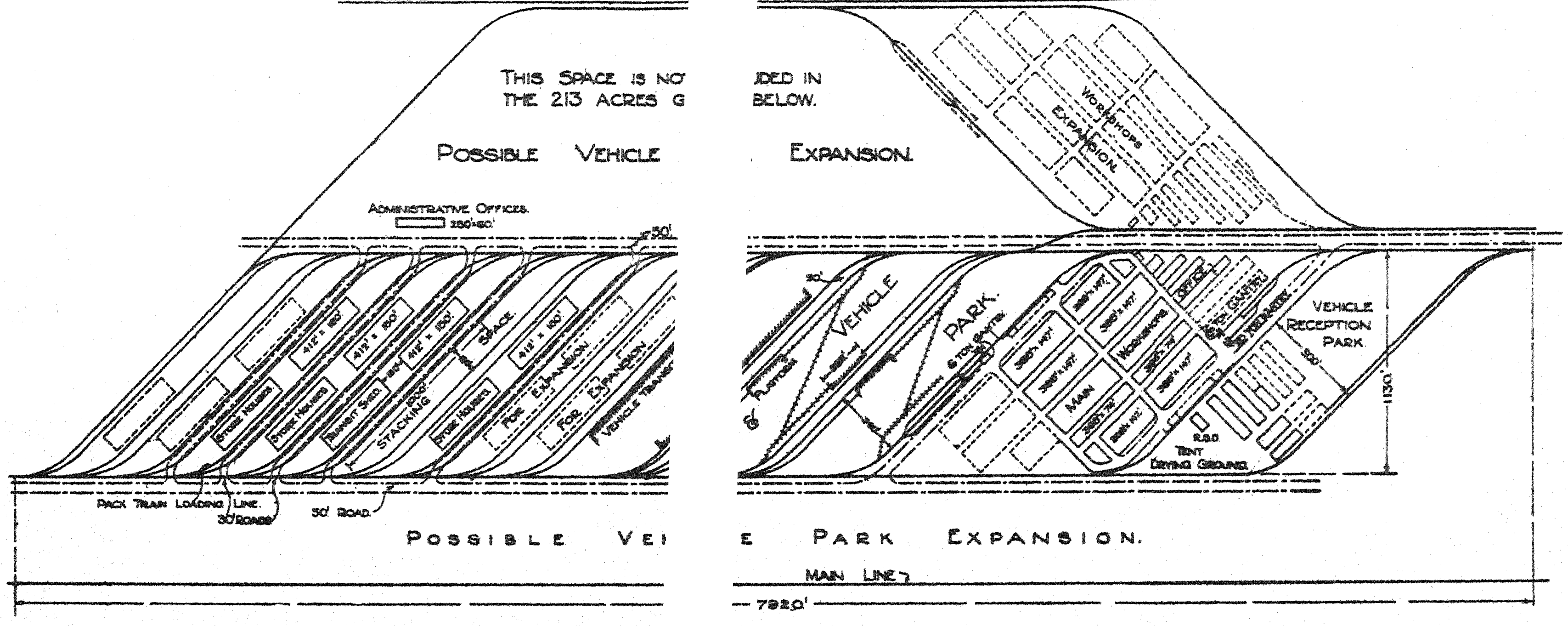
INSULATED HOSPITAL WARD.



BASE OR ANCE DEPOT

R A —

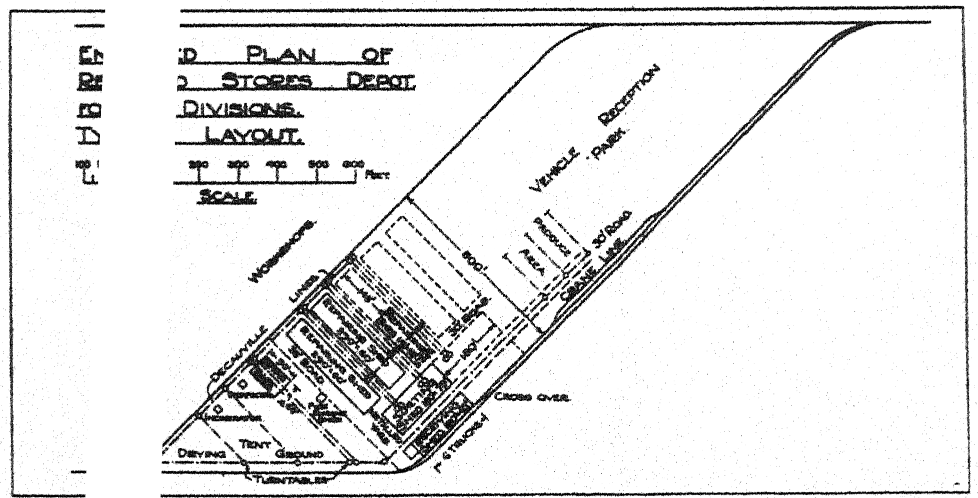
FORCE OF 5 INFANTRY DI NS AND 1 CAVALRY DIVISION.
INCLUDING SPACE FOR ANSION UP TO 20 DIVISIONS.



TOTAL ACREAGE REQUIRED TO ACCOMMODATE DEPOT GRID, INCLUDING GRIDS FOR WORKSHOP EXPANSION, BUT EXCLUSIVE OF RECEPTION AND DEPARTURE. SIDINGS:—
213 ACRES.

IF AN ADVANCED ORDNANCE DEPOT, IS OPENED, THE STOREHOUSES CAN BE REDUCED BY 2.

IF THE CONFIGURATION OF THE GROUND DOES NOT PERMIT OF THIS LAYOUT, MODIFICATIONS MAY BE NECESSARY AS INDICATED IN MANUAL OF MILY. ENGING. VOL. VIII, PLATE 6.

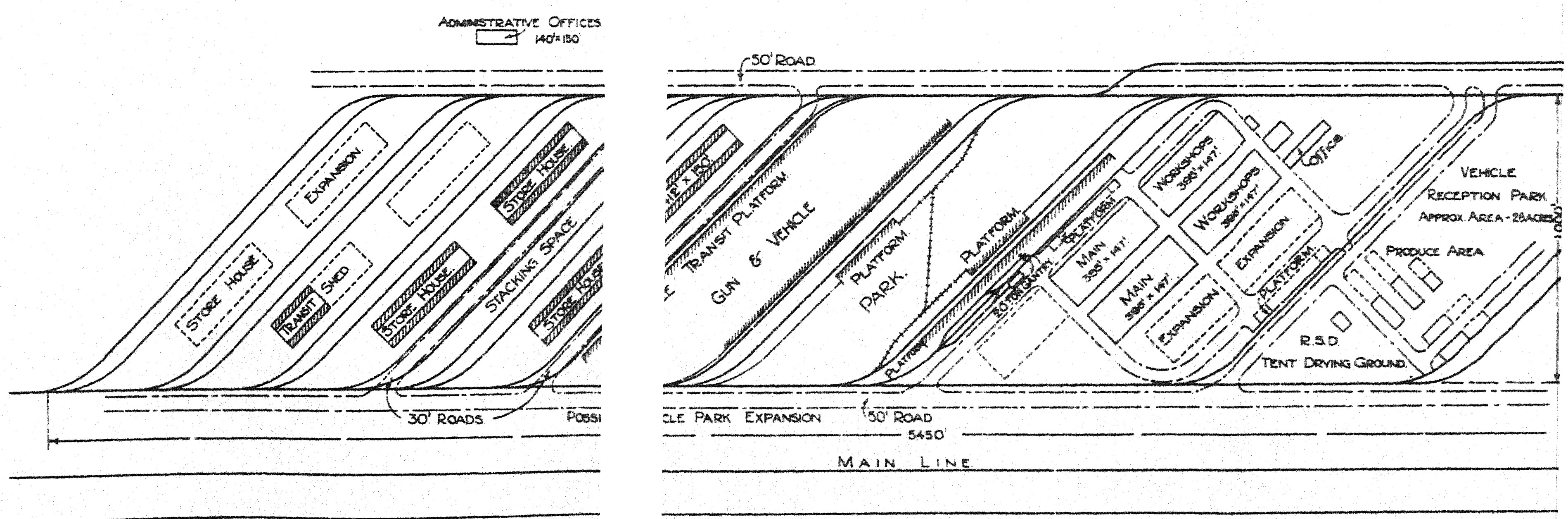


ADVAN[illegible] [illegible]D ORDNANCE DEPOT.

TOTAL ACREAGE REQUIRED TO ACCOMODATE DEF[illegible] D,
EXCLUSIVE OF ARRIVAL AND DEPARTURE SIDINGS [illegible] ACRES.
THE SIZE OF SHOPS AT THE BASE AND ADVANCED [illegible] WILL DEPEND
UPON A DECISION TO BE MADE IN THE THEATRE OF OPE[illegible] REGARDING
THE VOLUME OF REPAIR WORK TO BE UNDERTAKEN IN [illegible] ED AREAS

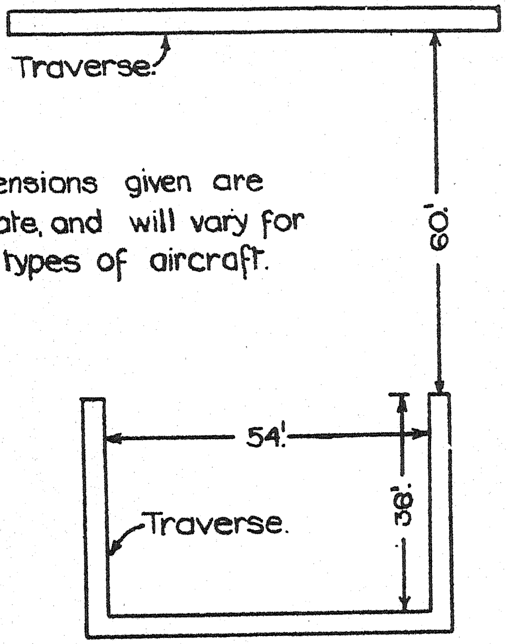
COVERED ACCOMODATION

WORKSHOPS	4 -	395' x 147' = 240,000 SQ. FT.
STOREHOUSES.	4 -	425' x 100' = 170,000 SQ. FT.
R.S. DEPOT	2 -	145' x 60'
	1 -	90' x 75'
	1 -	90' x 45'
	1 -	75' x 60' = 32,700 SQ. FT.

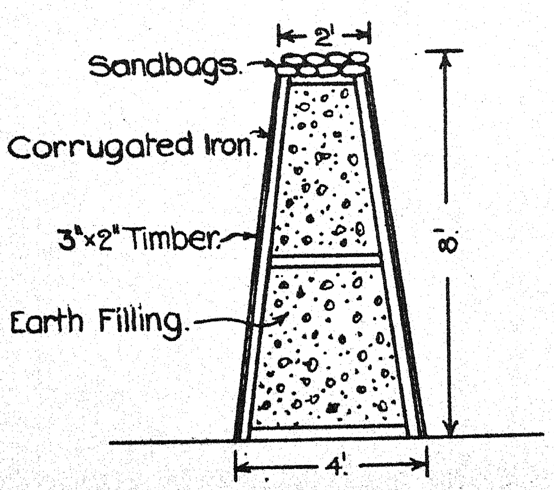


AEROPLANE STABLES.

The dimensions given are approximate, and will vary for different types of aircraft.



Plan of Stables.



Section through Traverse.

ROLLER SHUTTER & FRAME FOR 14'6" HIGH SHED.